the Hanford Site would be closed following the remediation of all sites, and the further assumption that any contaminants at substantial levels in the subsurface would be covered with a proven infiltration and intrusion barrier. A Modified RCRA Subtitle C barrier has been proposed for waste sites receiving surface barriers on the central plateau. Thus, the long-term exposure scenarios do not include intrusion as a source of contamination.

L.2.8 Uncertainty

The SAC was designed to provide a stochastic simulation capability able to quantify uncertainty through a Monte Carlo analysis. An uncertainty analysis can be completed for the SAC results. The goal of such an uncertainty analysis is to determine the model parameters that contribute the most variability to the performance measures. Results of the stochastic realizations can also be used to reveal the maximum – minimum range of performance measures.

The uncertainty analysis addresses the role of uncertainty as caused by the variation of parameters within the modeling systems. It does not address causes of errors between modeled and observed data. It does not address uncertainty due to the use of different models. In addition, the analysis of uncertainty does not differentiate between uncertainties due to lack of knowledge and uncertainty due to natural variability in the parameters.

The uncertainty analysis can identify controlling sources of variability in the simulation estimates of the performance measure, but not necessarily the source of the overall magnitude of the performance measure. However, the source of the overall magnitude is obtained from direct examination of model results.

The uncertainty analysis technique employed is a step-wise linear regression analysis using the output results and input parameters of an assessment. Because the SAC uses a sequential analysis structure (i.e., analysis progressively treats inventory, release, vadose zone, etc.), a top-down hierarchal analysis is performed to identify first tier quantities (e.g., derived quantities like tritium concentration in groundwater), and associated second tier parameters (e.g., unsaturated hydraulic properties, distribution coefficient) responsible for variability.

The initial assessment (Bryce et al. 2002) demonstrated that a relatively small number of input parameter could determine most of the variability in calculated performance measures. It was observed that when the performance measure is human dose, variability with regard to individual behavior and exposure affects uncertainty in the estimated dose more than variability in inventory, release, or environmental transport of the contaminants.

L.3 Results

Results of the initial assessment for a 10,000-year period conducted using the SAC software are presented below in three sections. Section L.3.1 details the release of contamination to the groundwater from the vadose zone. Section L.3.2 presents the drinking water dose that occurs from a 2-L/d drinking water exposure to groundwater at various points in the environment. Section L.3.3 presents the drinking water dose from consumption of water in the Columbia River at the City of Richland pump station.

L.3.1 Release to Groundwater Results

Releases to the unconfined aquifer from the vadose zone predicted using the SAC software and data are summarized in this section. Vadose zone releases to the groundwater are aggregated into the following categories for the numerous vadose zone sites simulated:

- Solid waste disposal facilities (only '218' sites)

- Tanks (only '241' sites)

- Liquid discharge ('216' sites plus unplanned release sites and the State Approved Land Disposal Site)

- Environmental Restoration Disposal Facility

- Commercial low-level radioactive waste disposal (referred to as the US Ecology site)

- Other sites in 200 East or 200 West Areas not included in the above categories

- All sites not in 200 East or 200 West Areas (that is, 100, 300, 400, and 600 Areas)

For each result, both annual releases and the cumulative of all annual releases (undecayed) are presented. Note, releases from ILAW, melters, and naval reactor compartments are omitted. The stochastic capability of the SAC was employed for these simulations, so the following results are shown in each plot:

- individual stochastic results (25 realizations)

- the median result of the 25 realizations—that is, the realization that resulted in the median cumulative release in the year 12050 A.D. (at the end of the simulation) is emphasized.

- the median-inputs simulation—that is, a separate single-realization simulation with SAC using the median value of all stochastic input variables.

The median result as defined by the cumulative release to the groundwater is highlighted in both the annual release and cumulative release plots. Each new pair of annual and cumulative plots identifies a new median case from the 25 realizations simulated.

The annual release plots have the appearance of being either a series of piecewise constant (stair-step) values or a smooth continuous curve. This is a function of the temporal resolution of both the release model and the vadose zone simulation. Piecewise constant curves result when the release rate is constant over a period of time and the vadose zone model is able to adopt relatively long time steps (for example, hundreds of years). When either the release or vadose zone model use a fine time step to forecast a more variable release, the release to groundwater appears as a smooth and continuous curve. In reality, both curves are a series of piecewise constant values; however, the fine temporal resolution of the more continuous curve give it the smooth appearance.

Figures L.3 through L.10 present the vadose zone release to groundwater results for the sum of all solid waste disposal facilities. Each cumulative plot showing the 25 stochastic realizations provides information on the range of cumulative response as well as the median for solid waste disposals. Cumulative releases to groundwater for solid waste disposed of in the Central Plateau range from approximately 323 to approximately 445 Ci for technetium-99 during the 10,000-year analysis period. However, for uranium the release is nil—none in any realization in the 200 East Area and only 5 of 25 realizations exhibit any release in 200 West Area. The median solutions for both 200 East and 200 West Areas are zero essentially.

Figures L.11 through L.18 present the results for vadose zone releases to groundwater for the sum of all tank sites. Cumulative releases to groundwater for tank waste (that is, past leaks, future losses, and residuals) in the Central Plateau range from approximately 440 to approximately 645 Ci for technetium-99 during the 10,000-year analysis period. As in the case of solid waste, uranium in tank waste does not exhibit substantial release during the 10,000-year period. Only 5 of 25 realizations show uranium release from 200 East Area tank sites, and hence, the median release is zero. For 200 West Area tank sites, the median case predicts release of approximately 1 Ci of uranium to groundwater during the entire 10,000-year period.

Figures L.19 through L.26 present the vadose zone release to groundwater results for the sum of all liquid discharge and unplanned release (UPR) sites and (in the case of 200 West) the SALDS facility. Cumulative releases to groundwater for liquid releases in the Central Plateau range from approximately 735 to approximately 1030 Ci for technetium-99 during the 10,000-year analysis period. The vast majority of this activity is associated with 200 East Area. The liquid release of uranium ranges between approximately 5 and approximately 100 Ci for the Central Plateau with median values of approximately 26 Ci for 200 East Area and approximately 5 Ci for 200 West Area.

Figures L.27 through L.38 present the results for vadose zone releases to groundwater for the sum of all other sites (sites in 200 East and 200 West Areas, excluding solid waste burial ground, tank, liquid discharge, unplanned release, ERDF, and commercial low-level radioactive waste disposal sites) and for the sum of all sites outside the 200 East and 200 West Areas (that is, the 100, 300, 400, and 600 area sites). Cumulative releases to groundwater for all other sites (for example, canyons, tunnels) on the Central Plateau range from approximately 15 to approximately 50 Ci for technetium-99 during the 10,000-year analysis period. The majority of this activity is associated with 200 West Area. Negligible releases of uranium occur from these sites. Cumulative releases to groundwater from sites away from the Central Plateau (for example, river corridor sites with residual contamination) range from approximately 17 to approximately 37 Ci for technetium-99 during the 10,000-year analysis period. The release of uranium from these same sites ranges from approximately 5 to approximately 80 Ci. Note that the river corridor includes several liquid waste disposal trenches that received fuel fabrication waste streams that carried uranium to the vadose zone.

Figures L.39 through L.42 present the results for vadose zone releases to groundwater for the ERDF. Cumulative releases to groundwater from the ERDF range from 0 to approximately 27 Ci for technetium-99 during the 10,000-year analysis period. As in the case of solid waste, uranium in the ERDF does not exhibit significant release during the 10,000-year period. Only 3 of 25 realizations exhibit any release, none before 7000 years post-closure. Hence, the median case shows no uranium release to groundwater.

Figures L.43 through L.46 present the results for vadose zone releases to groundwater for the commercial low-level radioactive waste disposal site operated by US Ecology, Inc. Cumulative releases to groundwater from the US Ecology site range from 0 to approximately 80 Ci for technetium-99 during the 10,000-year analysis period. The annual release curves (Figure L.43) and the cumulative plots (Figure L.44) exhibit substantial variability in the timing of release; however, the peak annual releases appear to vary between only approximately $2x10^{-2}$ and approximately $5x10^{-2}$ Ci/yr after 3000 A.D. As in the case of solid waste and ERDF, uranium in the US Ecology site does not exhibit release to groundwater during the 10,000-year period.

These results indicate that technetium-99 releases from the solid waste disposal facilities to groundwater of may account for approximately 323 to approximately 445 Ci in 10,000 years, and releases of uranium would be negligible. This contrasts with approximately 440 to approximately 645 Ci of technetium-99 from tank sites, approximately 735 to approximately 1030 Ci from liquid releases, approximately 15 to approximately 50 Ci from other sites on the Central Plateau, approximately 17 to approximately 37 Ci from sites away from the plateau, 0 to approximately 27 Ci from ERDF, and 0 to approximately 80 Ci from the US Ecology site. Overall, the comparison is approximately 323 to approximately 445 Ci of technetium-99 from solid waste and approximately 1530 to approximately 2310 Ci of technetium-99 released in 10,000 years from all Hanford Site sources. Thus, the contribution from Hanford solid waste would amount to about 20 percent of the cumulative technetium-99 release from all Hanford sources.

The release of uranium to groundwater from Hanford solid waste is much lower. No realizations showed any release of uranium to groundwater from Hanford solid waste in the 200 East Area, and only 5 of 25 realizations exhibit any release of uranium to groundwater from Hanford solid waste in 200 West Area. Thus, in an average, or median, sense, Hanford solid waste deposits would release no uranium to groundwater over the 10,000-year period of analysis. This result compares to a median release of approximately 84 Ci and a range of release to groundwater from the 25 realizations of between approximately 10 and approximately 300 Ci of uranium for all Hanford wastes. Of the five realizations of non-zero uranium release from Hanford solid waste in the 200 West Area, the range of cumulative release was 0 to approximately 94 Ci. Hence, the contribution to overall uranium release to the water table from Hanford solid waste lies between 0 and approximately 29 Ci, but the majority of realizations show zero release. As a consequence, the contribution from Hanford solid waste would amount to between 0 and 30 percent of the cumulative release from all Hanford sources. The majority of the technetium-99 and uranium release was forecast to occur from past liquid discharge sites (cribs, ponds, trenches) and unplanned releases on the plateau, and from off-plateau or river corridor waste sites.

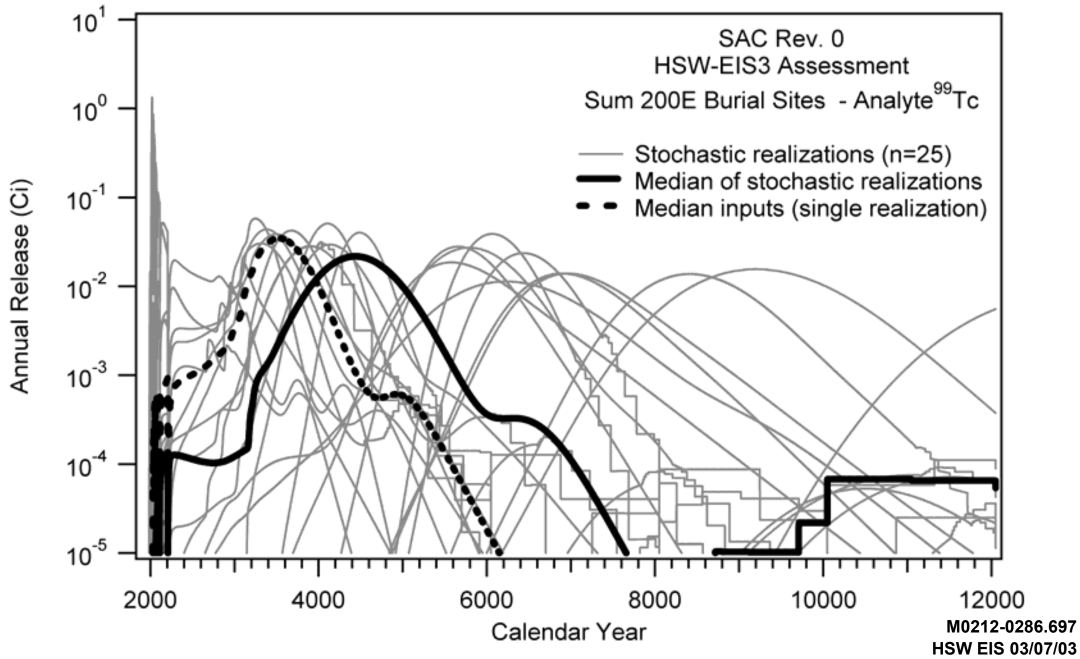

Figure L.3. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Solid Waste Disposal Facilities Sites in the 200 East Area (including all '218' sites except 218-E-14 and 218-E-15, and excluding ILAW)

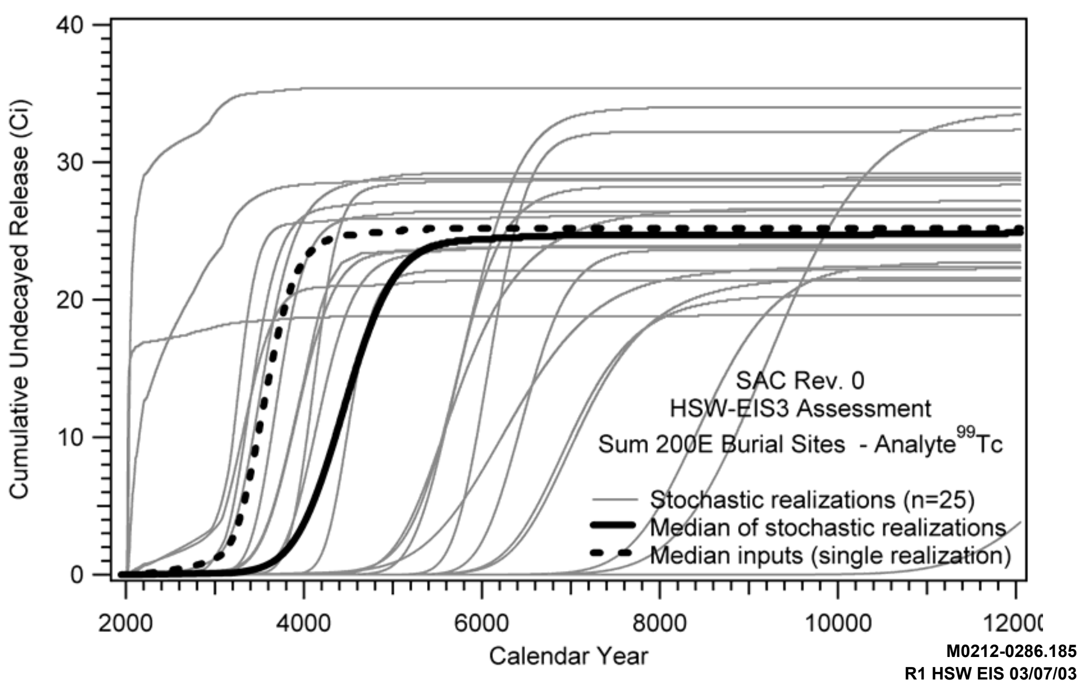

Figure L.4. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Solid Waste Disposal Facilities Sites in the 200 East Area (including all '218' sites except 218-E-14 and 218-E-15, and excluding ILAW)

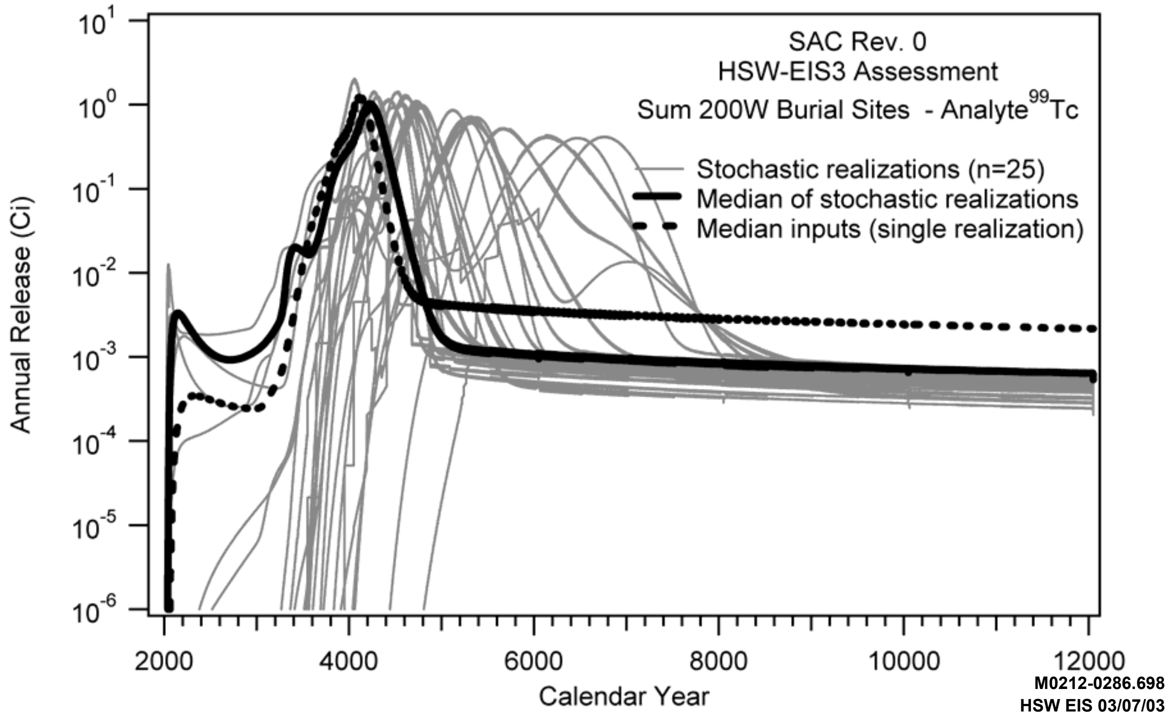

Figure L.5. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Solid Waste Disposal Facilities Sites in the 200 West Area (including all ‘218’ sites)

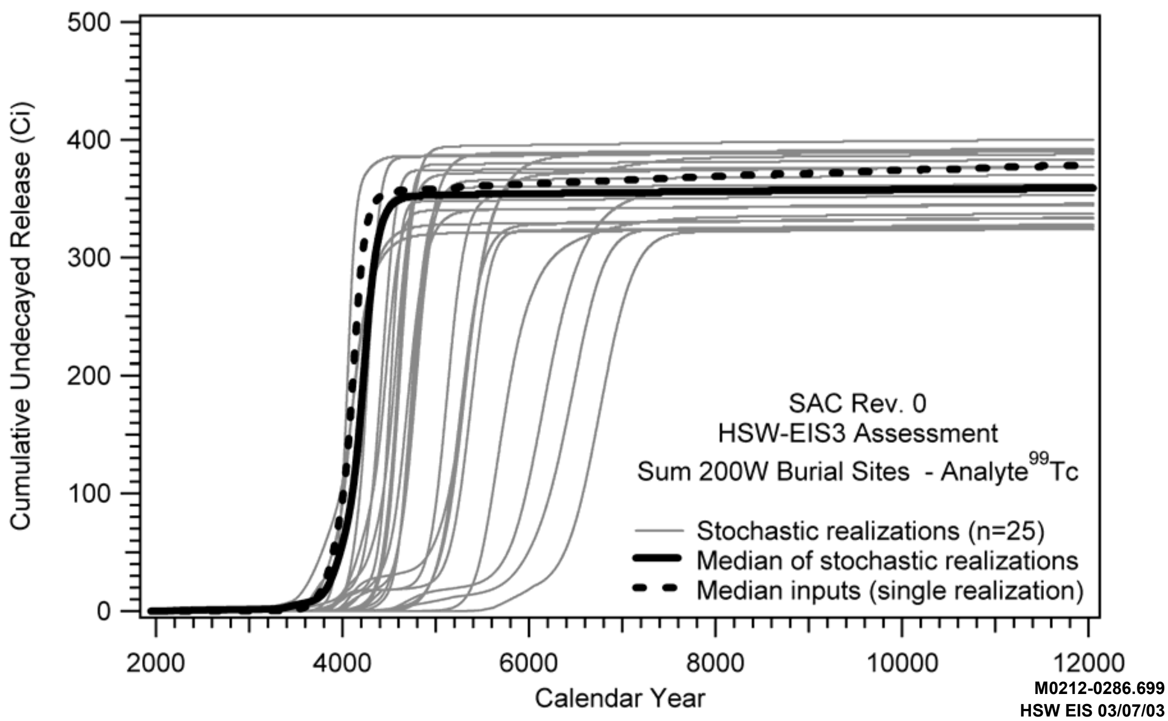

Figure L.6. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Solid Waste Disposal Facilities Sites in the 200 West Area (including all ‘218’ sites)

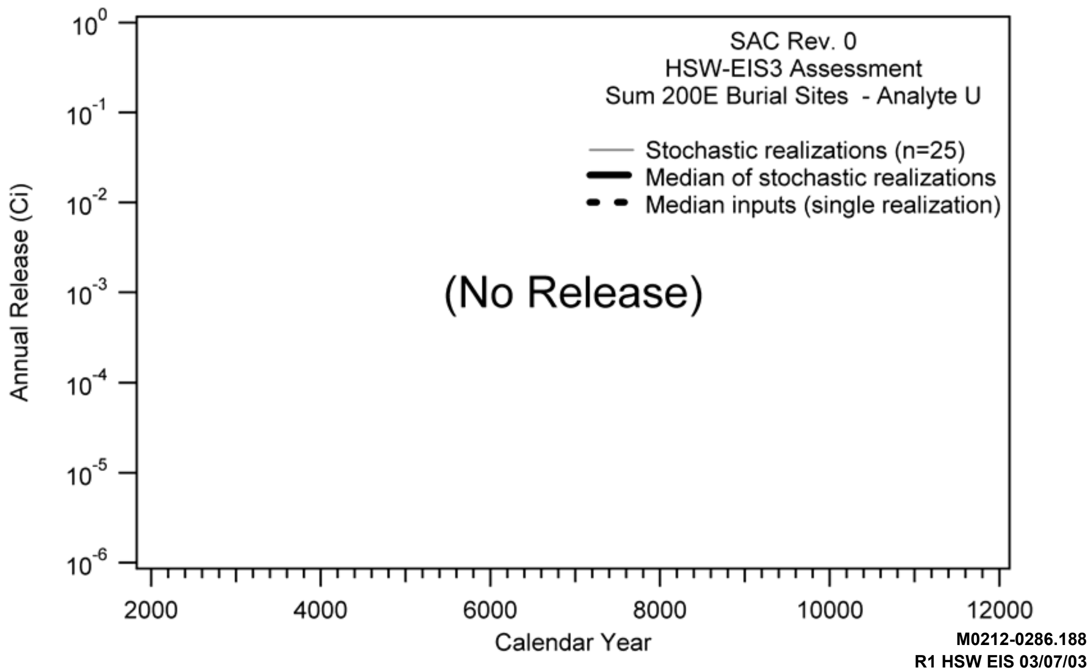

Figure L.7. SAC Results for Annual Vadose Zone Release of Uranium from All Solid Waste Disposal Facilities Sites in the 200 East Area (including all '218' sites except 218-E-14 and 218-E-15, and excluding ILAW)

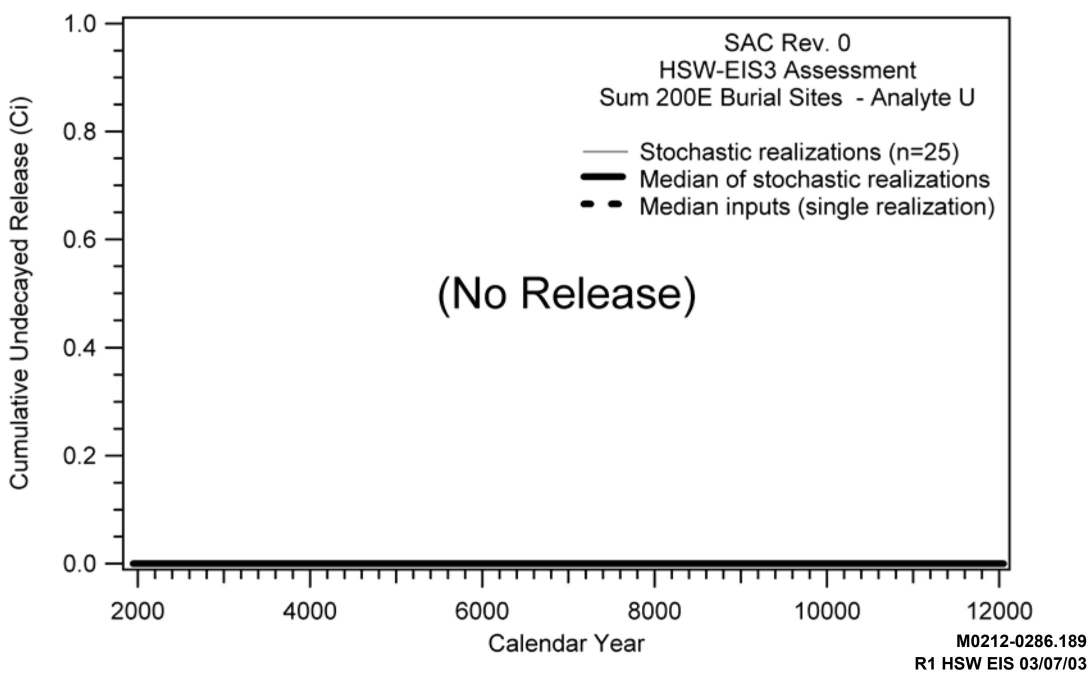

Figure L.8. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Solid Waste Disposal Facilities Sites in the 200 East Area (including all '218' sites except 218-E-14 and 218-E-15, and excluding ILAW)

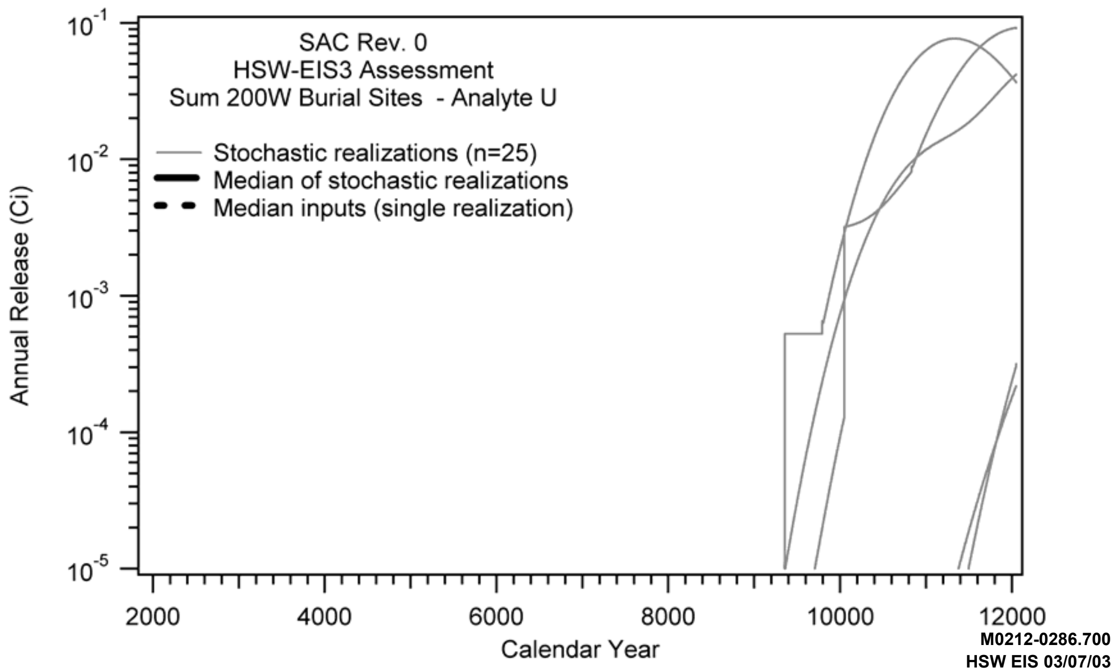

Figure L.9. SAC Results for Annual Vadose Zone Release of Uranium from All Solid Waste Disposal Facilities Sites in the 200 West Area (including all '218' sites)

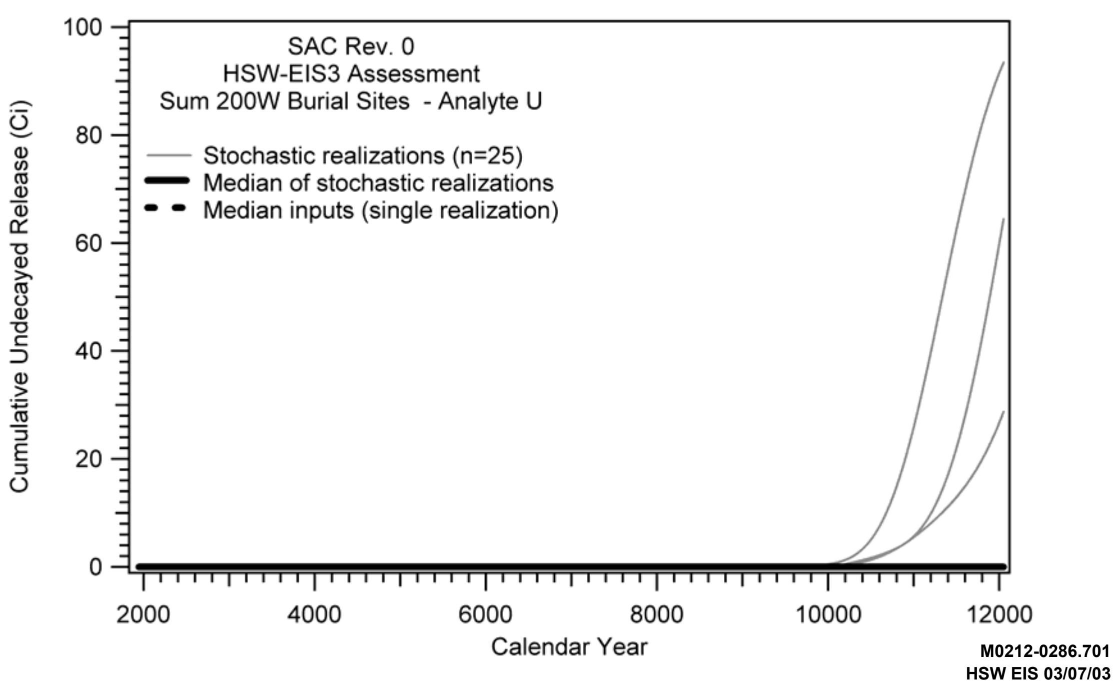

Figure L.10. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Solid Waste Disposal Facilities Sites in the 200 West Area (including all '218' sites)

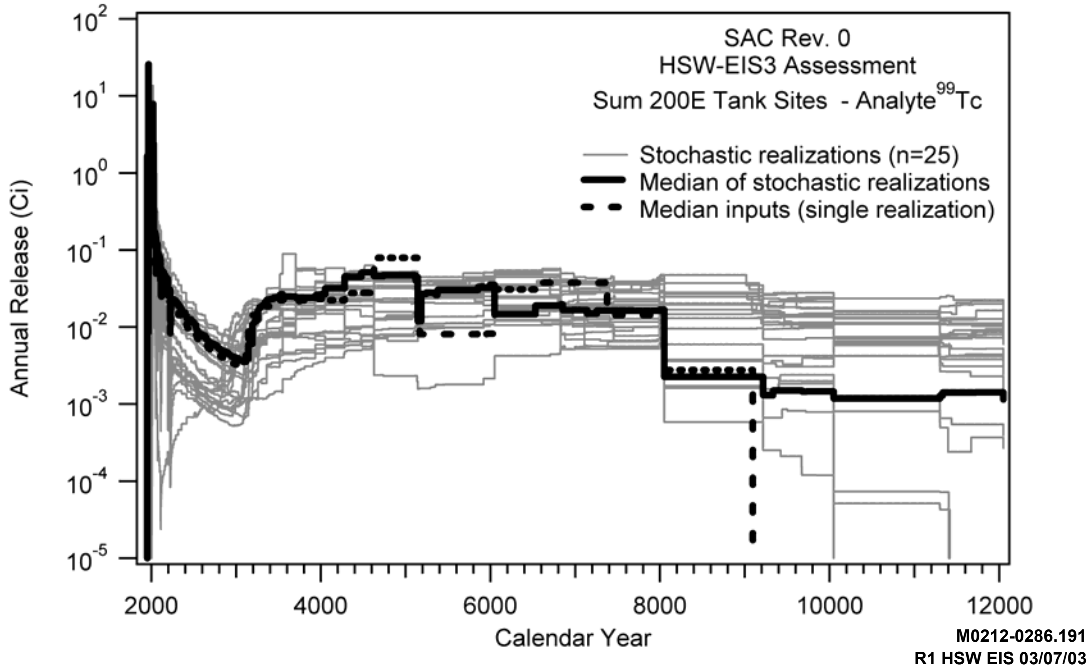

Figure L.11. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Tank Sites in the 200 East Area

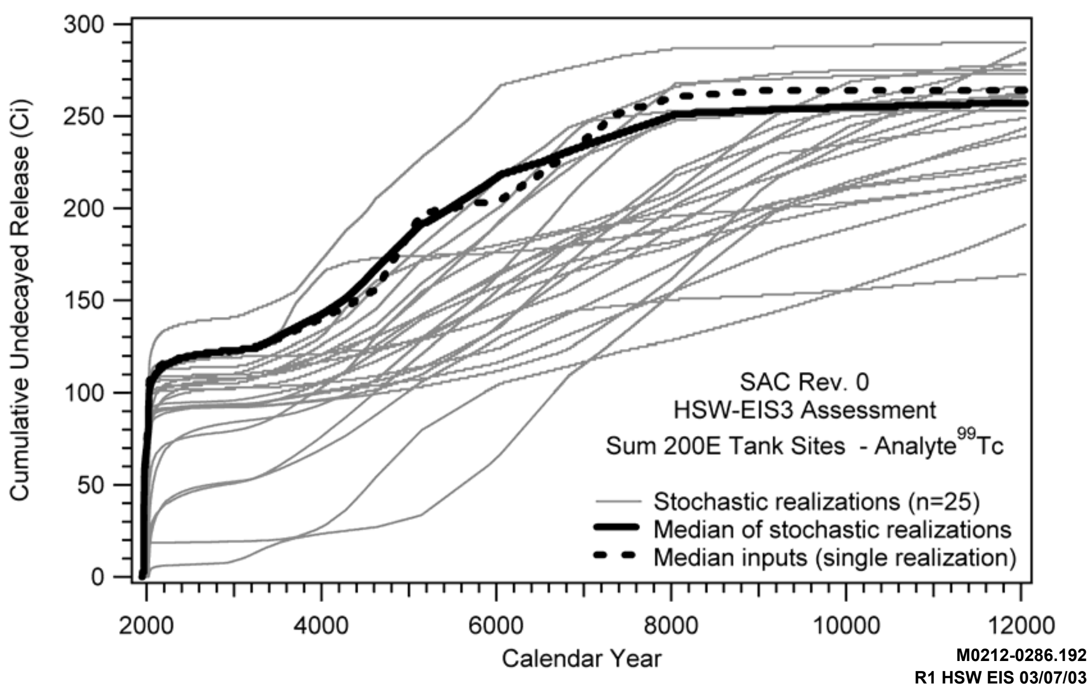

Figure L.12. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Tank Sites in the 200 East Area

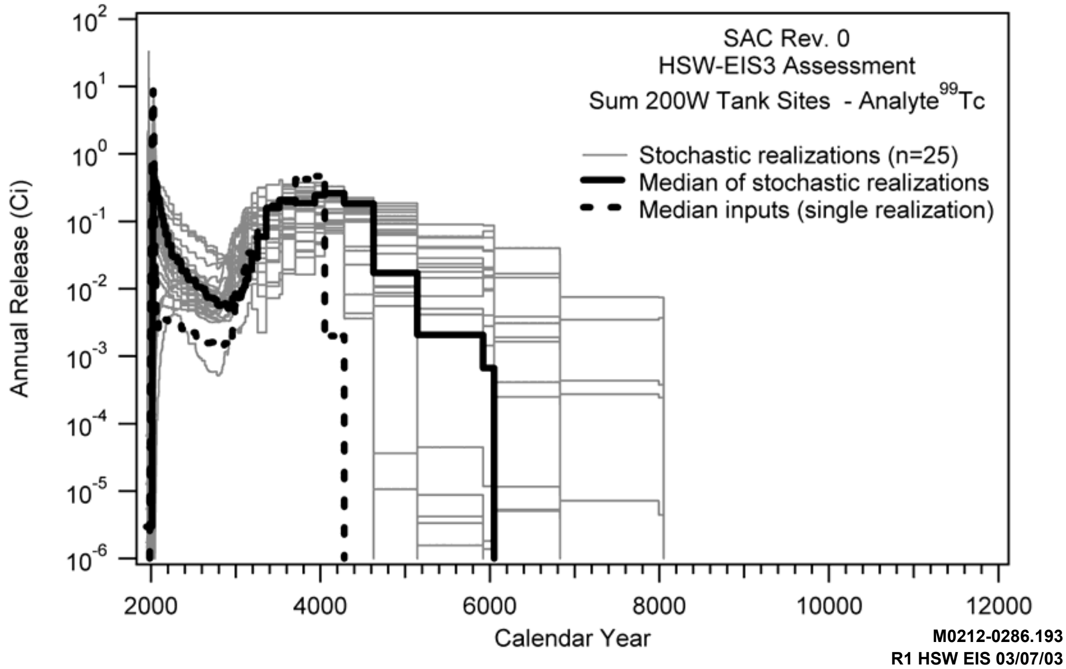

Figure L.13. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Tank Sites in the 200 West Area

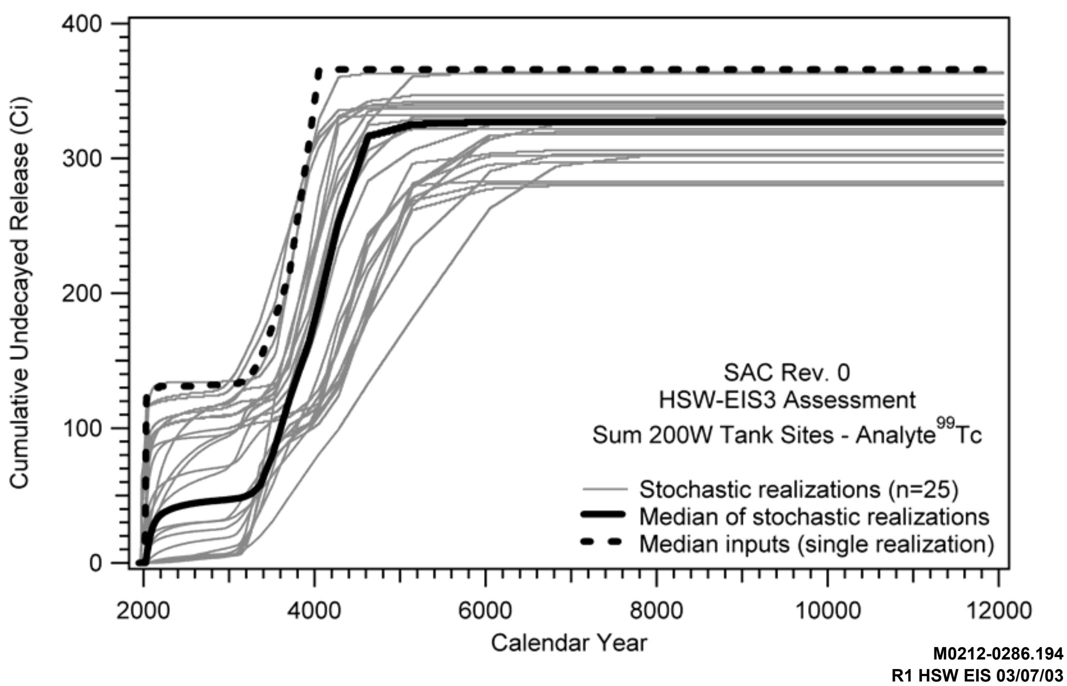

Figure L.14. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Tank Sites in the 200 West Area

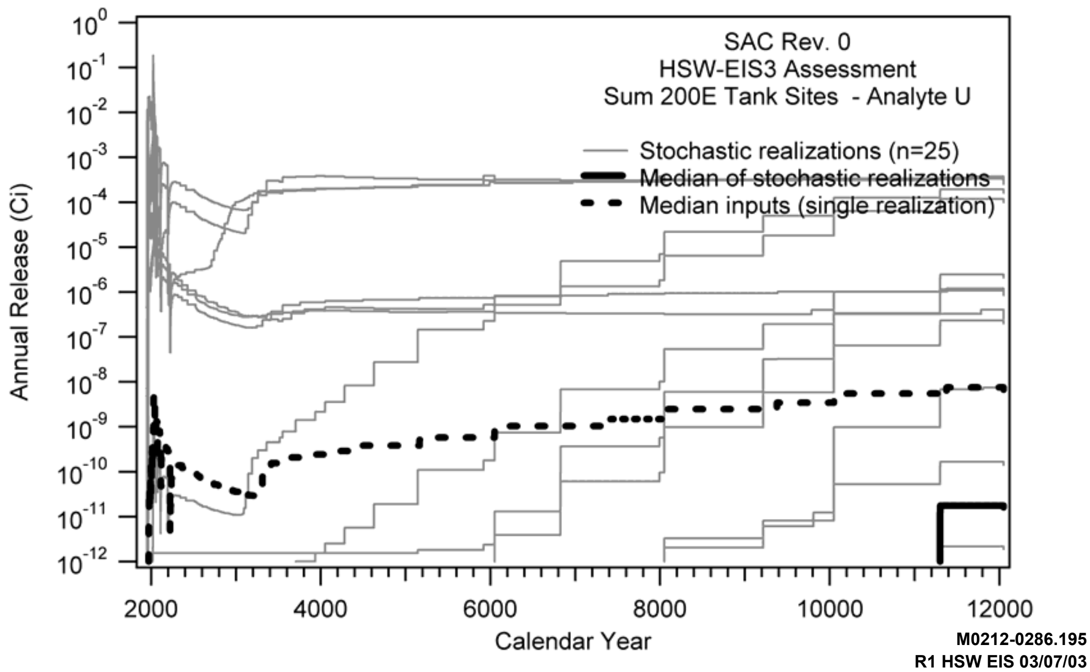

Figure L.15. SAC Results for Annual Vadose Zone Release of Uranium from All Tank Sites in the 200 East Area

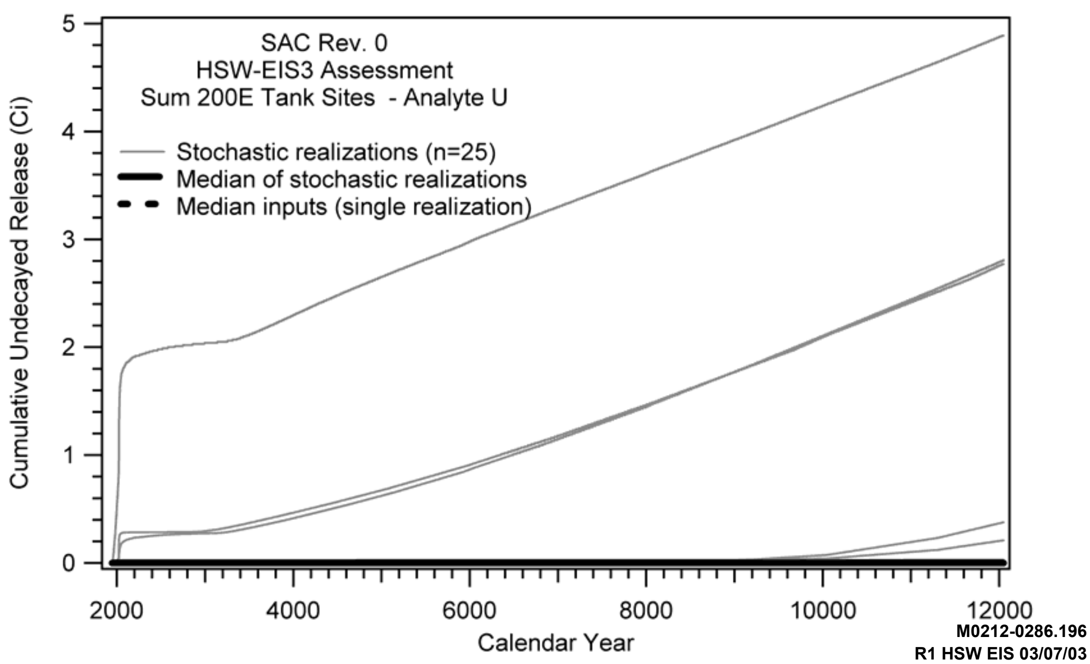

Figure L.16. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Tank Sites in the 200 East Area

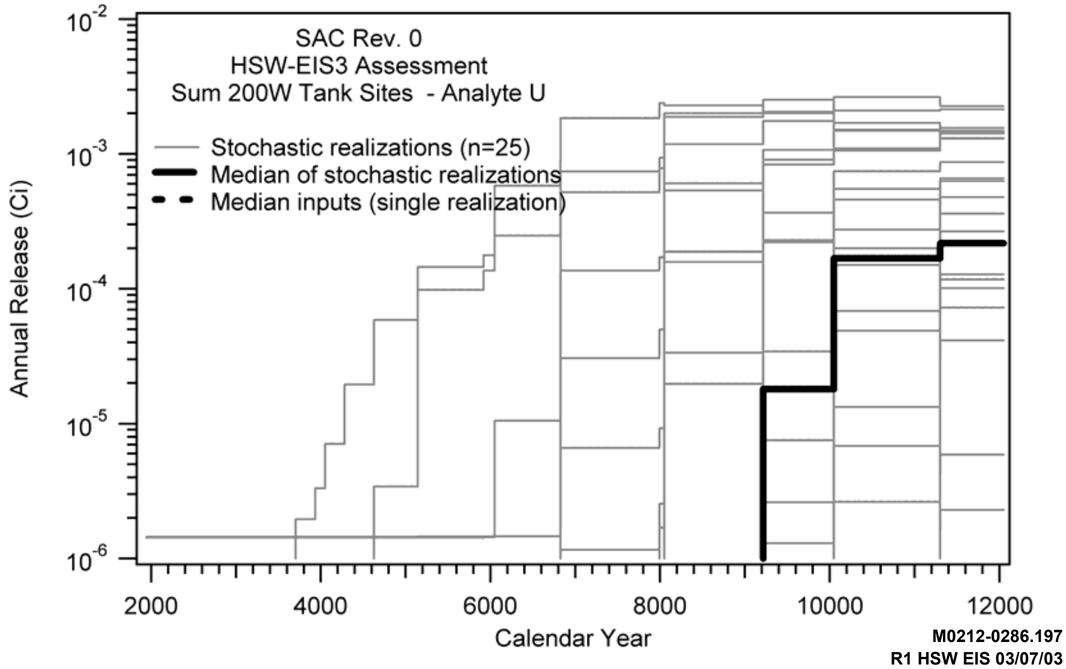

Figure L.17. SAC Results for Annual Vadose Zone Release of Uranium from All Tank Sites in the 200 West Area

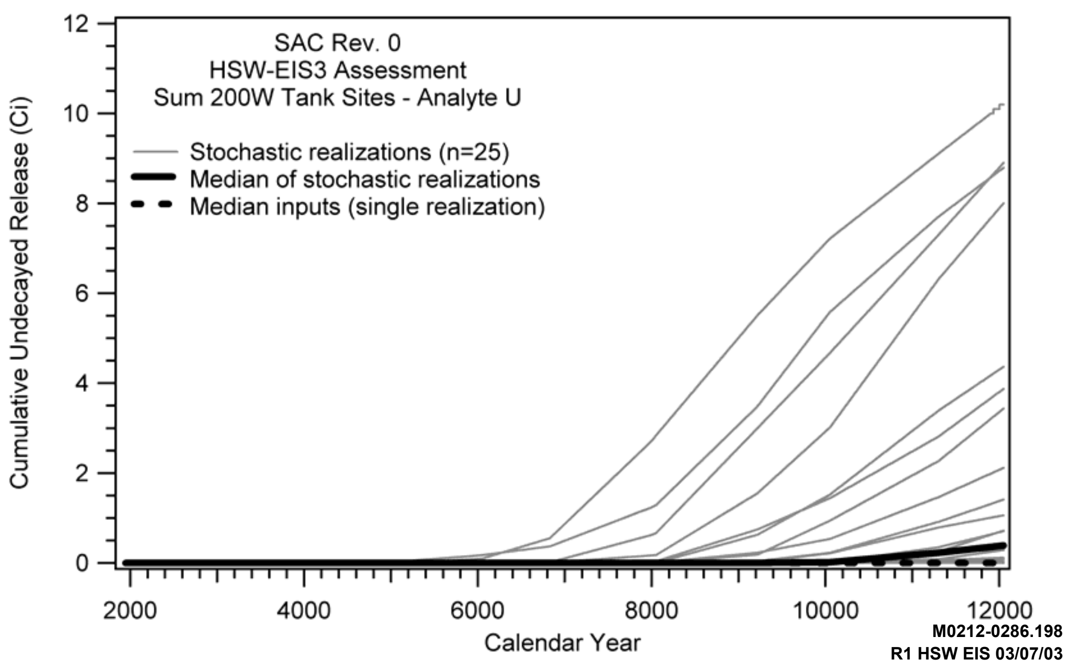

Figure L.18. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Tank Sites in the 200 West Area

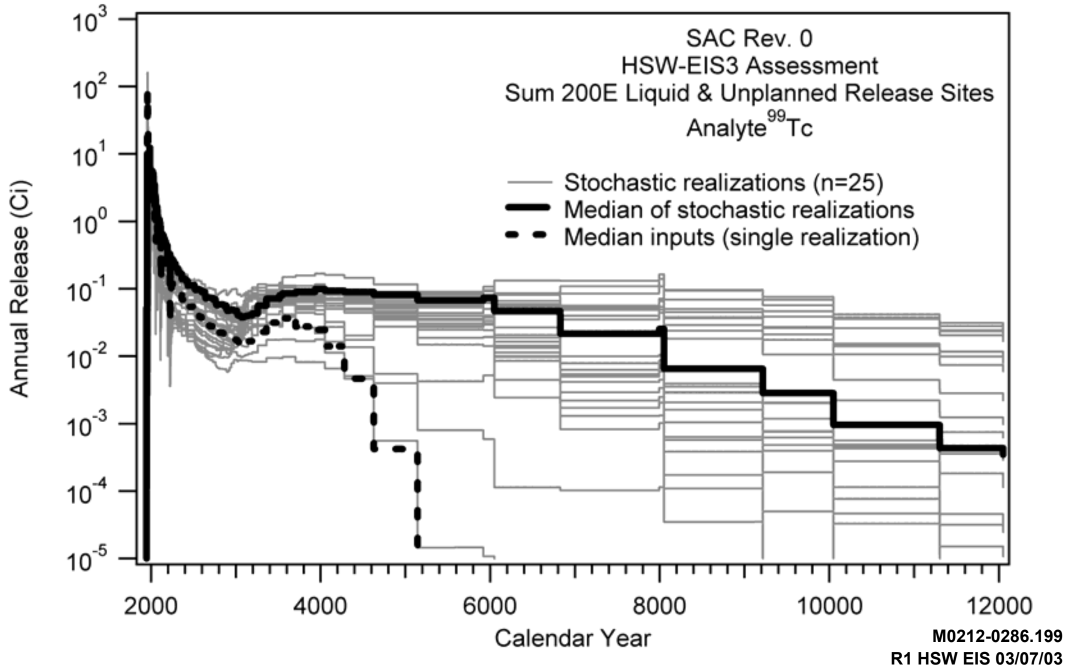

Figure L.19. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Liquid Discharge and Unplanned Release Sites in the 200 East Area

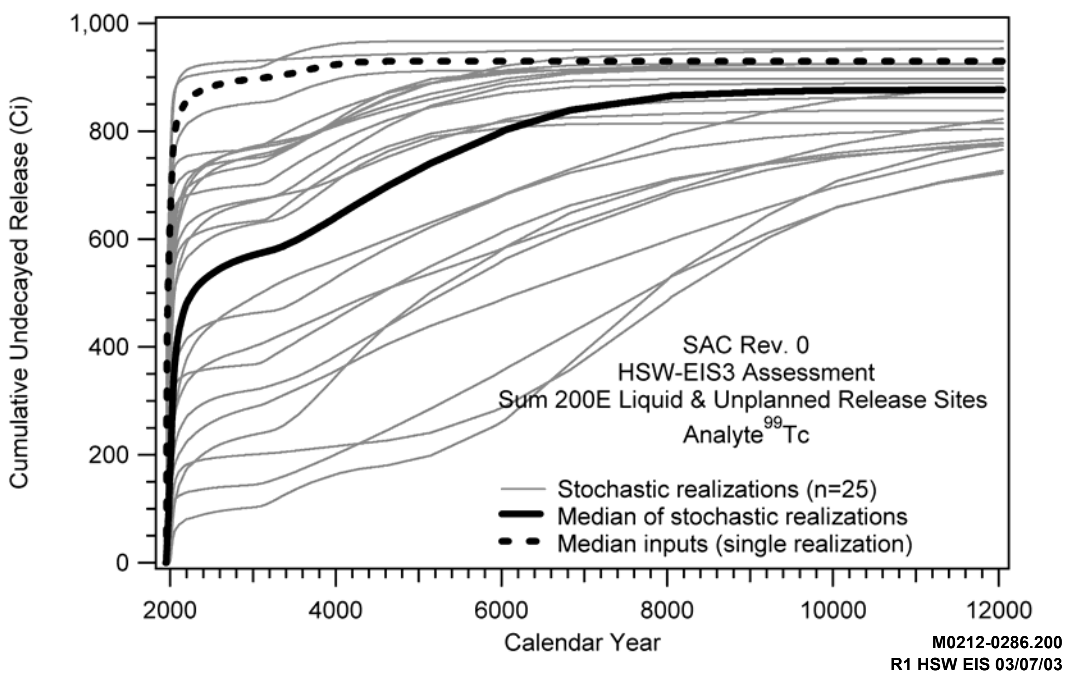

Figure L.20. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Liquid Discharge and Unplanned Release Sites in the 200 East Area

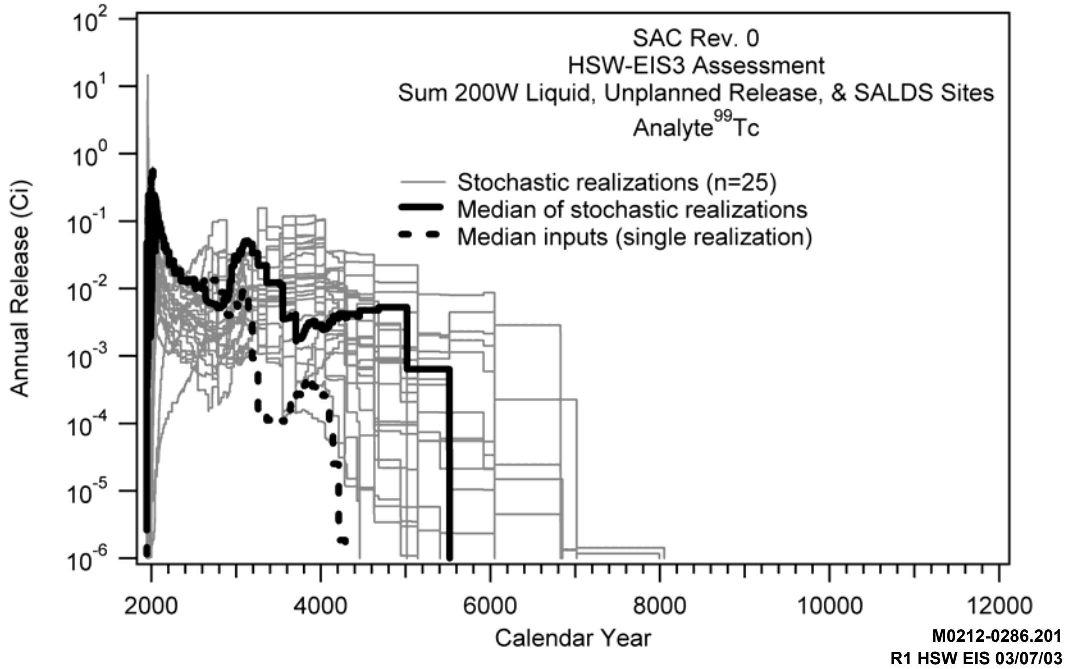

Figure L.21. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Liquid Discharge and Unplanned Release Sites in the 200 West Area Plus SALDS

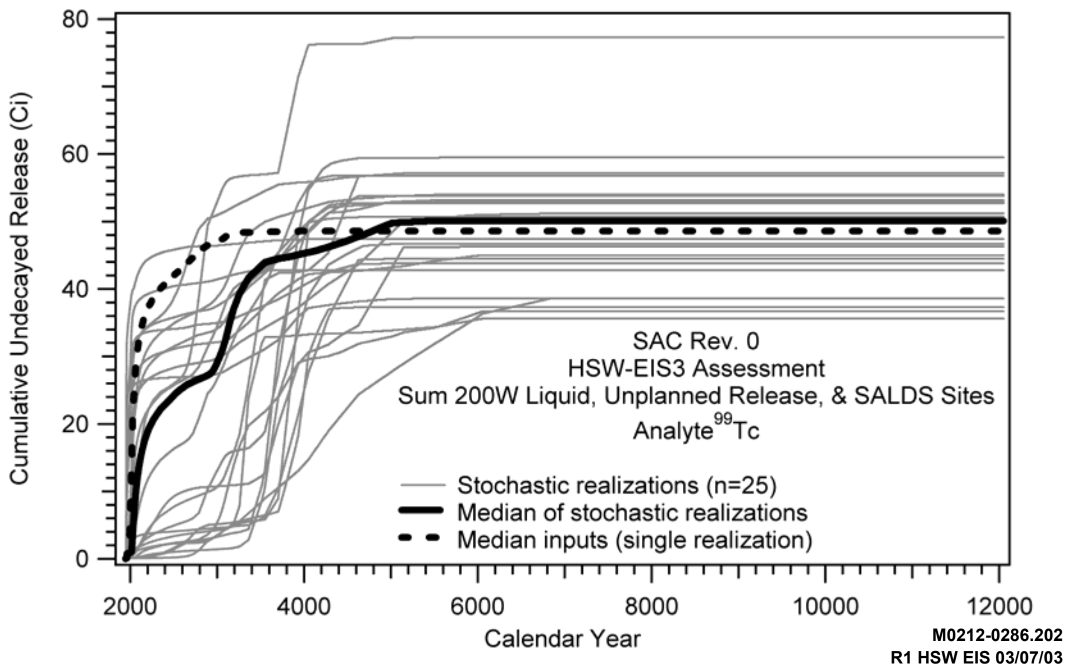

Figure L.22. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Liquid Discharge and Unplanned Release Sites in the 200 West Area Plus SALDS

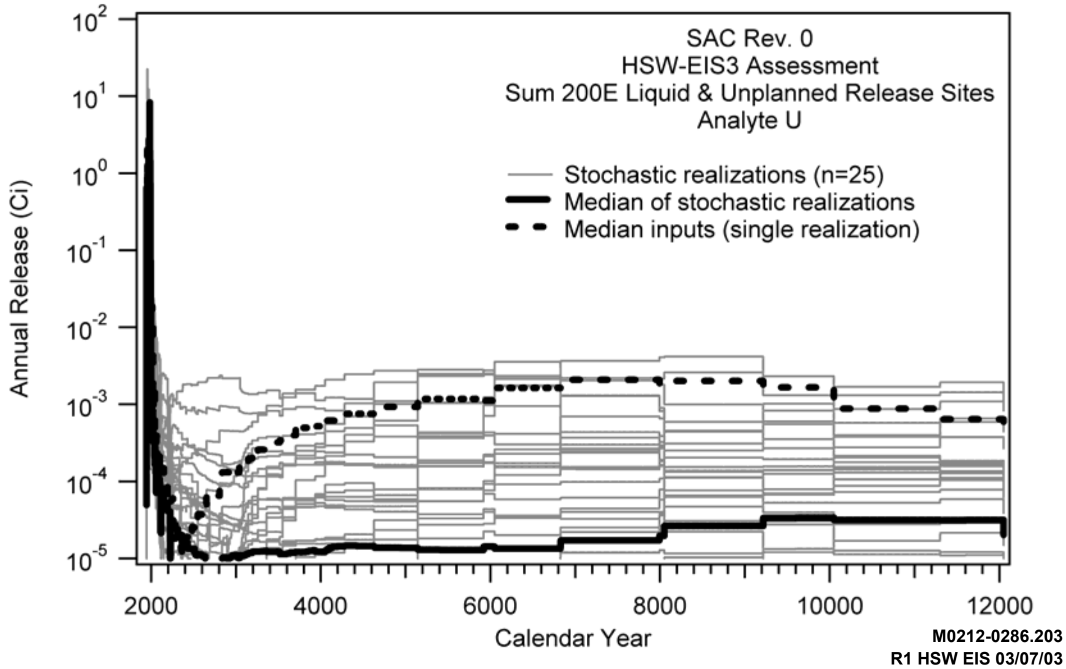

Figure L.23. SAC Results for Annual Vadose Zone Release of Uranium from All Liquid Discharge and Unplanned Release Sites in the 200 East Area

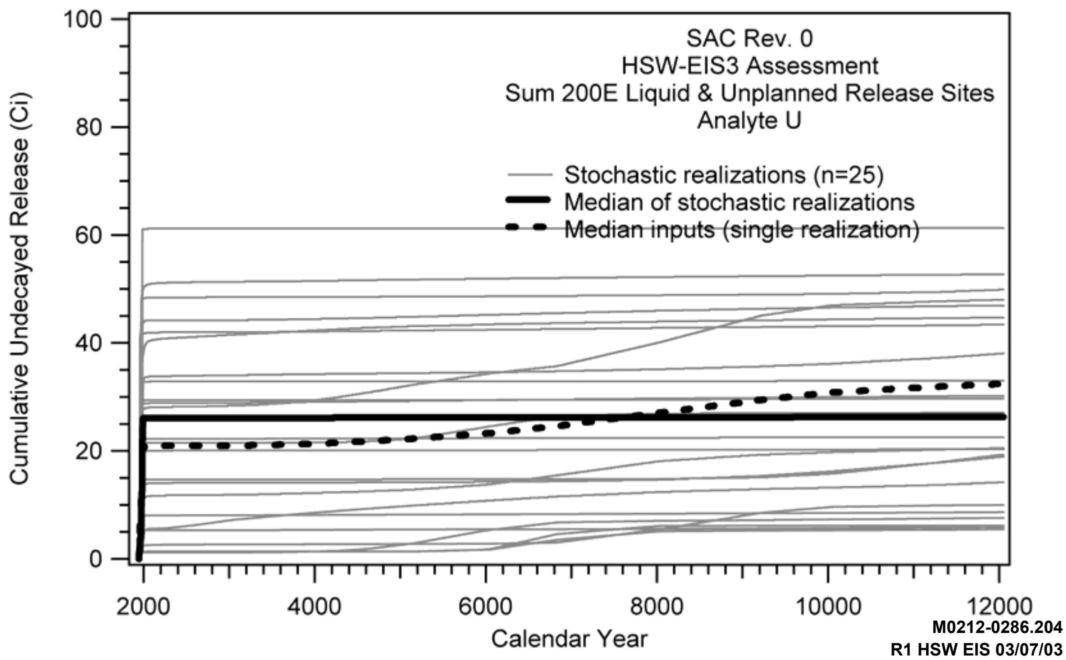

Figure L.24. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Liquid Discharge and Unplanned Release Sites in the 200 East Area

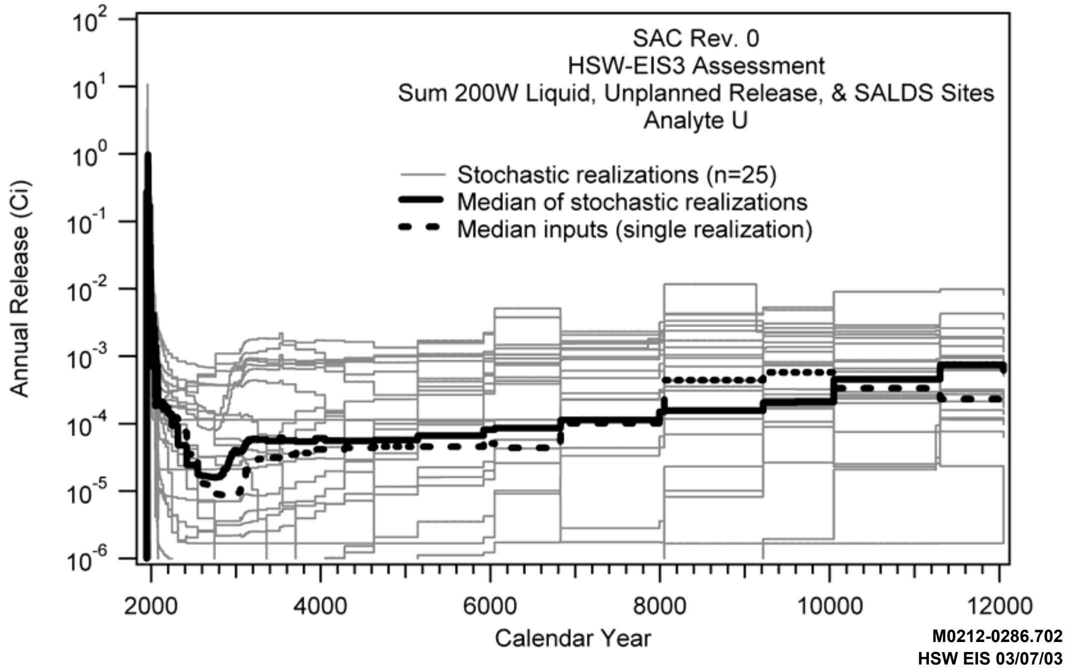

Figure L.25. SAC Results for Annual Vadose Zone Release of Uranium from All Liquid Discharge and Unplanned Release Sites in the 200 West Area Plus SALDS

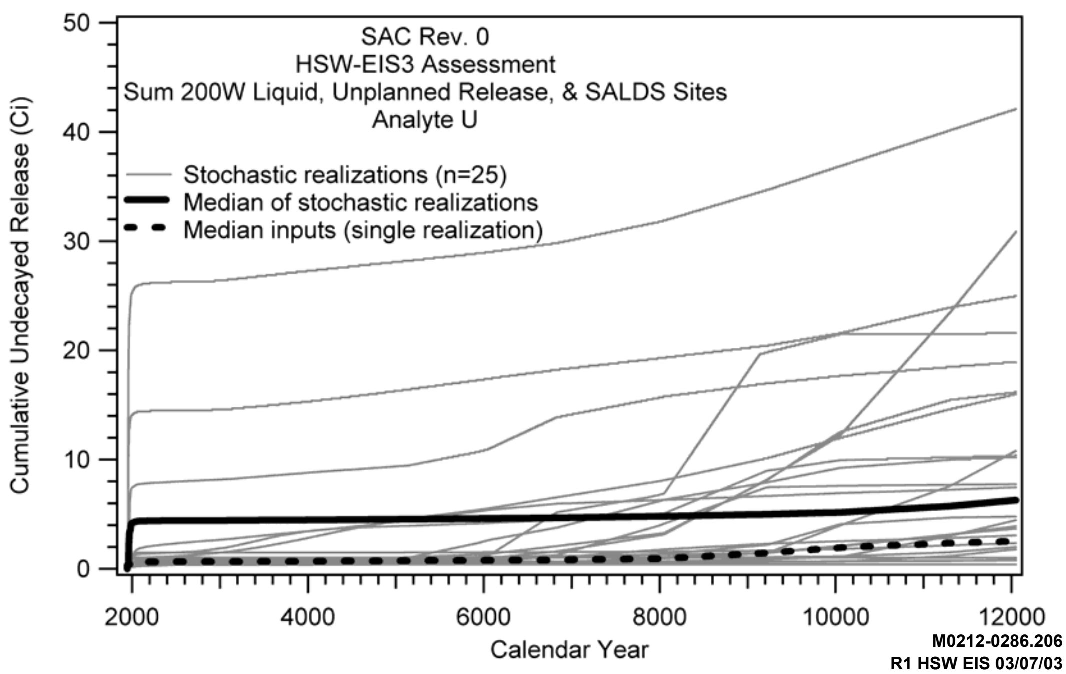

Figure L.26. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Liquid Discharge and Unplanned Release Sites in the 200 West Area Plus SALDS

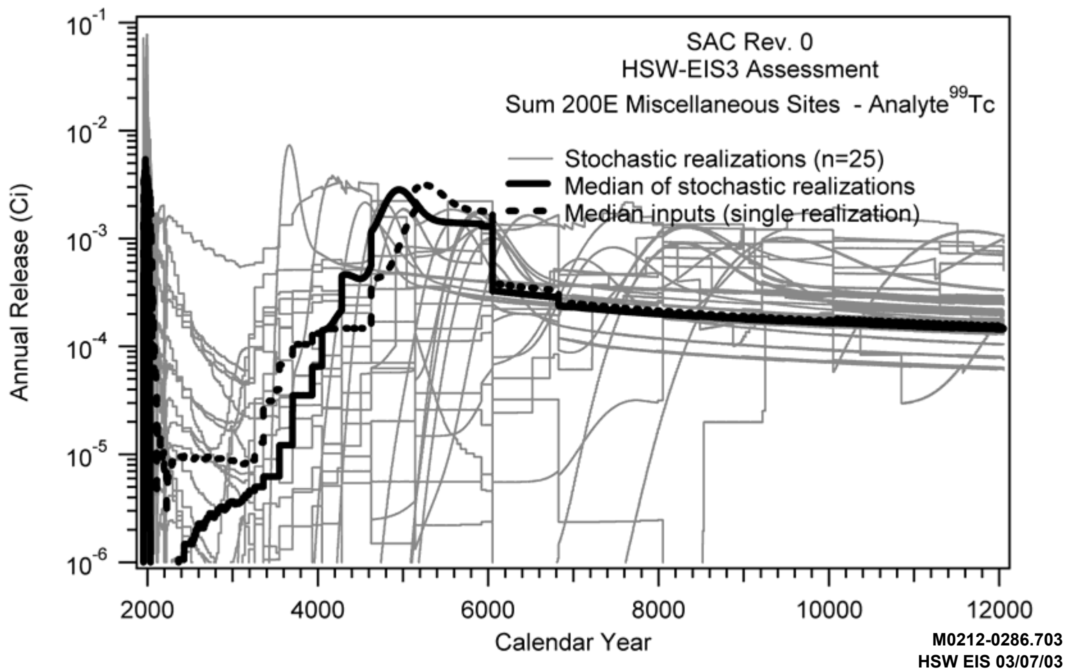

Figure L.27. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Other Sites in the 200 East Area

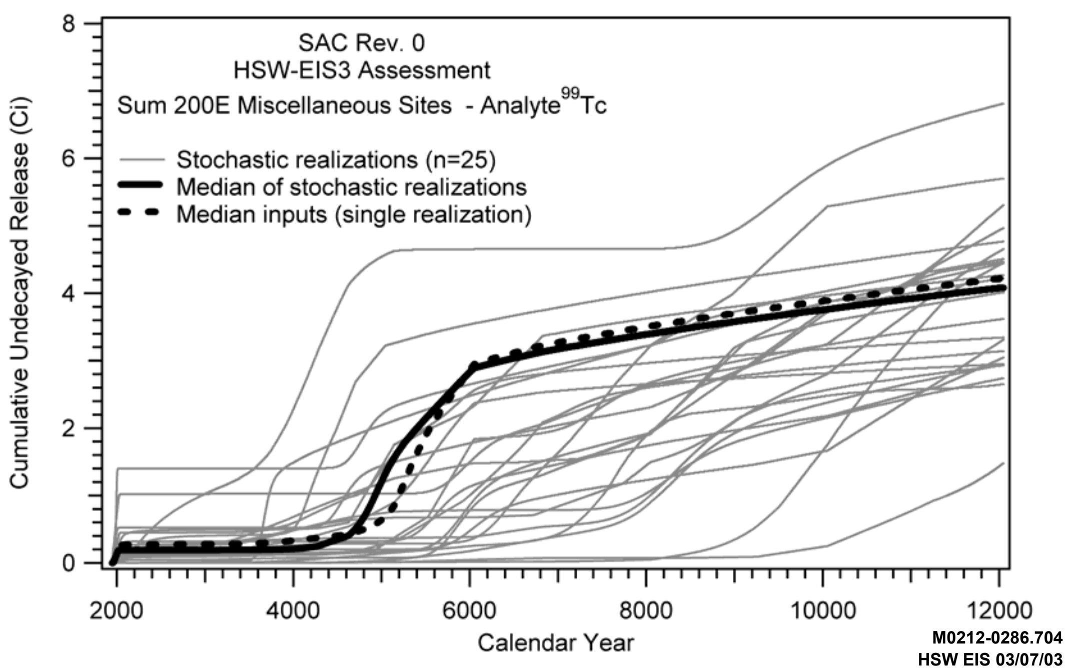

Figure L.28. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Other Sites in the 200 East Area

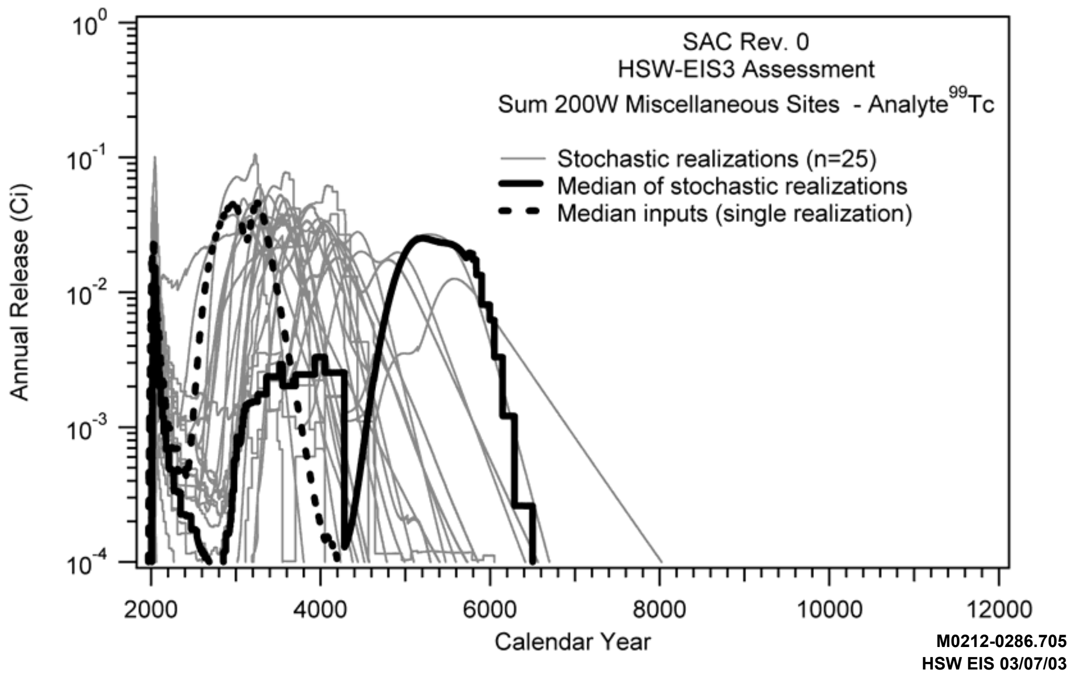

Figure L.29. SAC Results for Annual Vadose Zone Release of Technetium-99 from All Other Sites in the 200 West Area

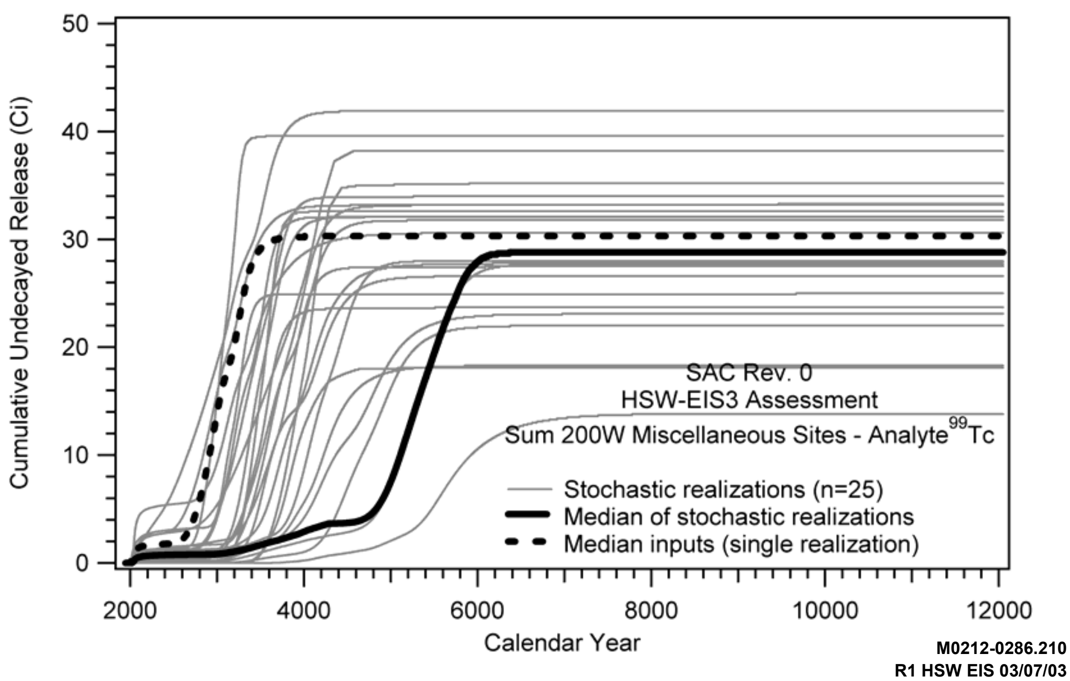

Figure L.30. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Other Sites in the 200 West Area

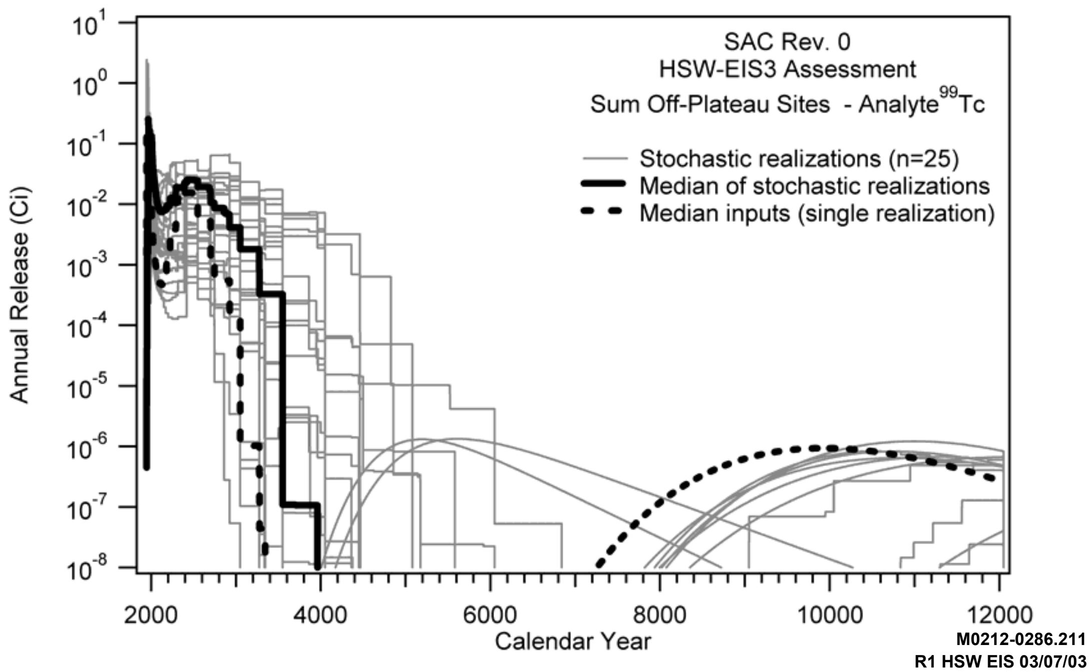

Figure L.31. SAC Results for Annual Vadose Zone Release of Technetium-99 from all Other Sites Outside the 200 East and 200 West Areas

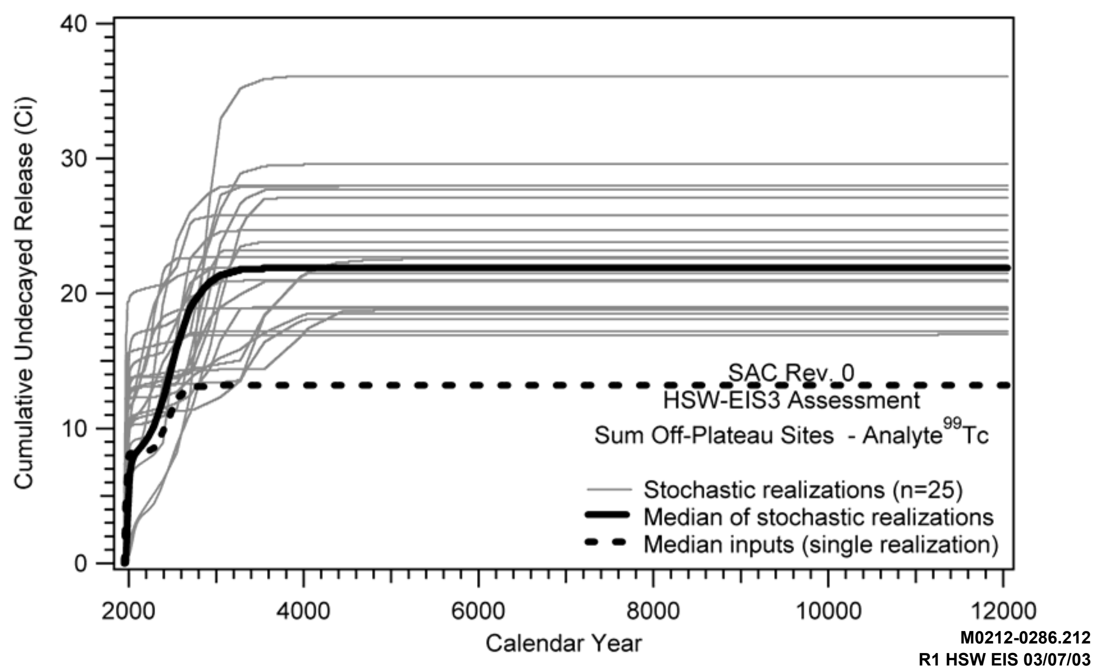

Figure L.32. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from All Other Sites Outside the 200 East and 200 West Areas

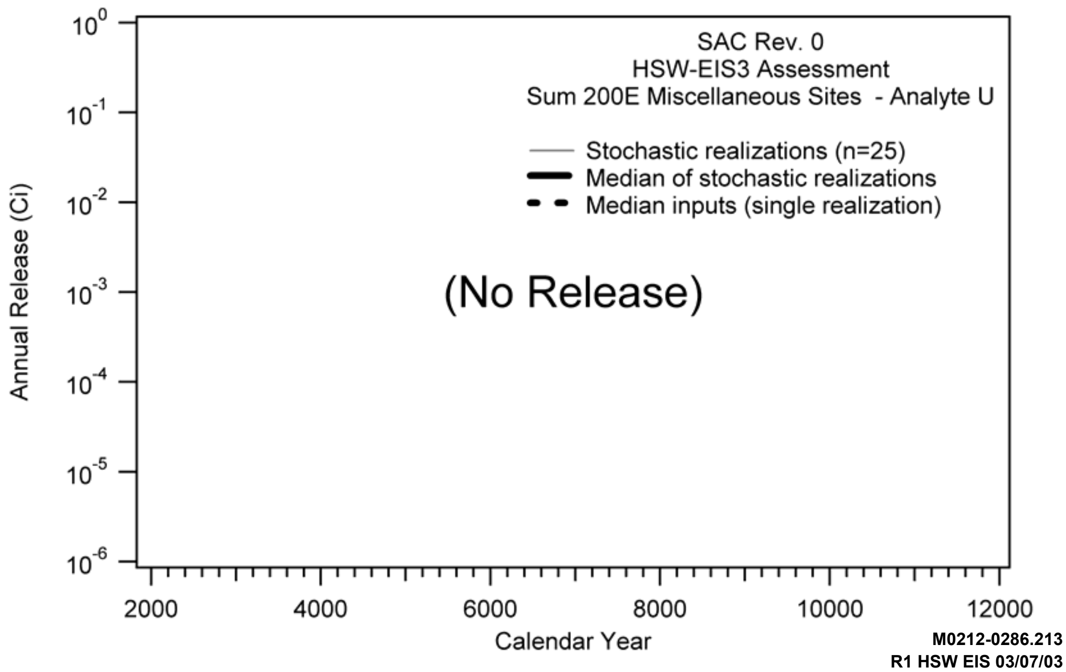

Figure L.33. SAC Results for Annual Vadose Zone Release of Uranium from All Other Sites in the 200 East Area

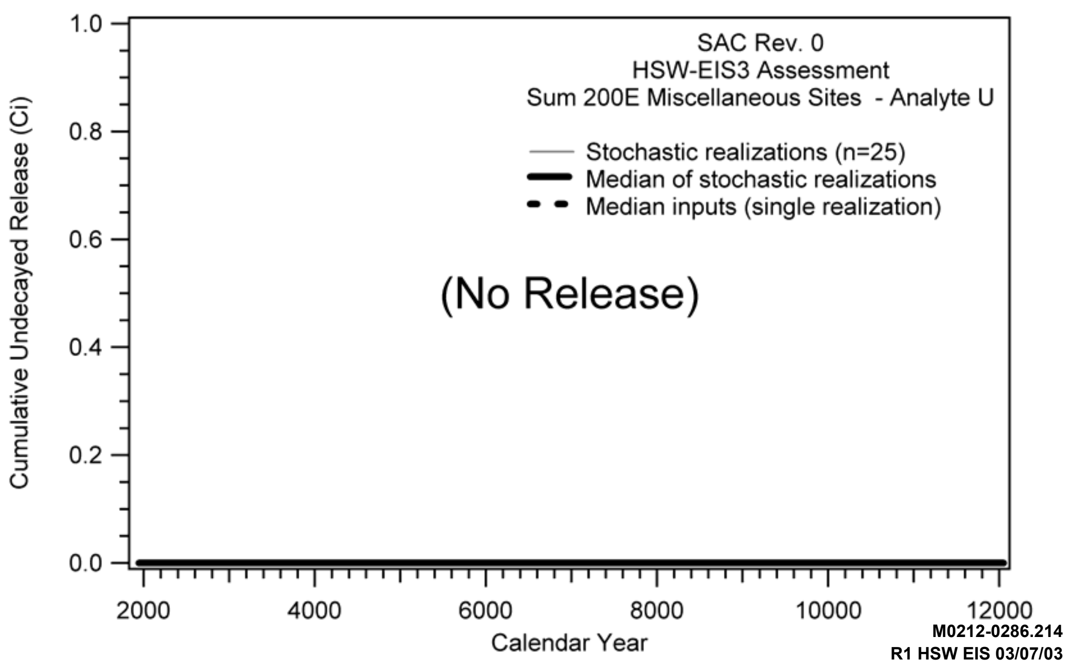

Figure L.34. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Other Sites in the 200 East Area

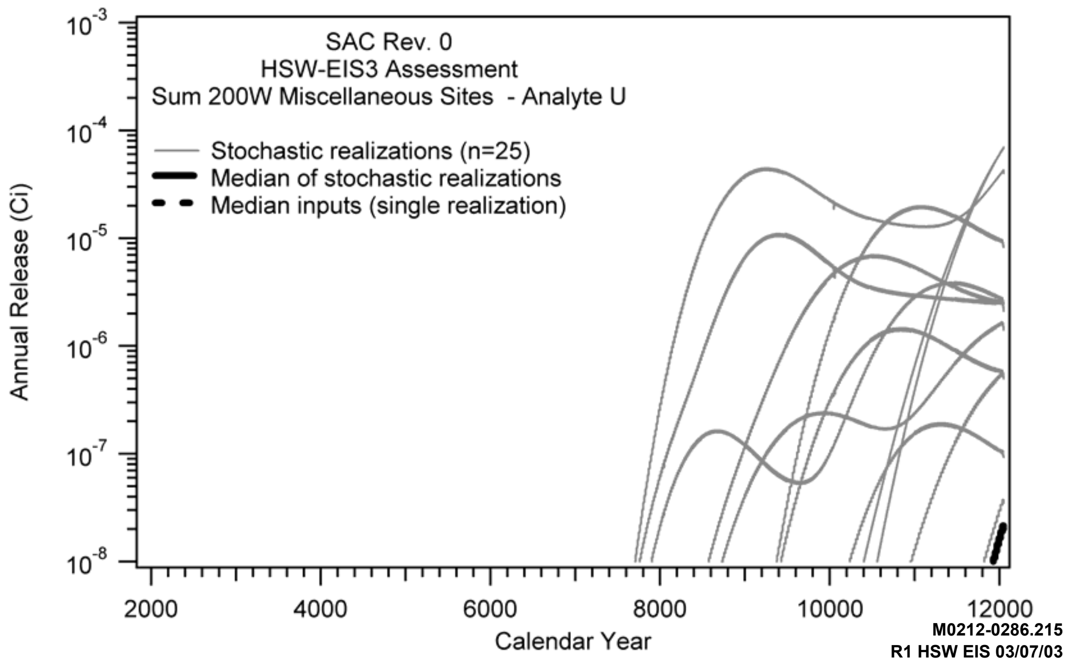

Figure L.35. SAC Results for Annual Vadose Zone Release of Uranium from All Other Sites in the 200 West Area

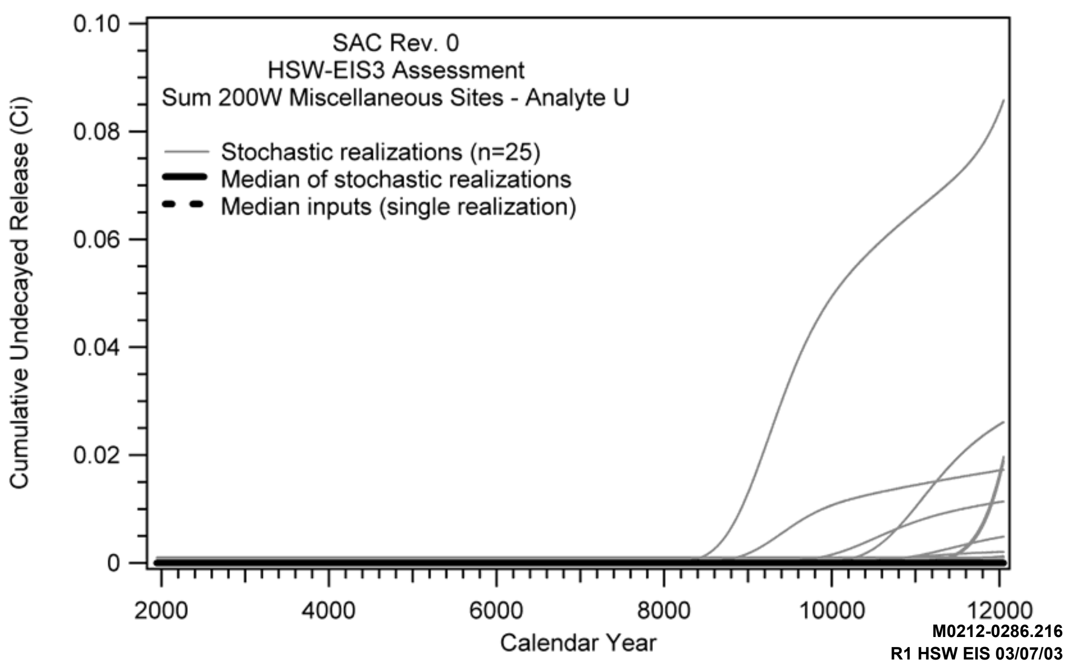

Figure L.36. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Other Sites in the 200 West Area

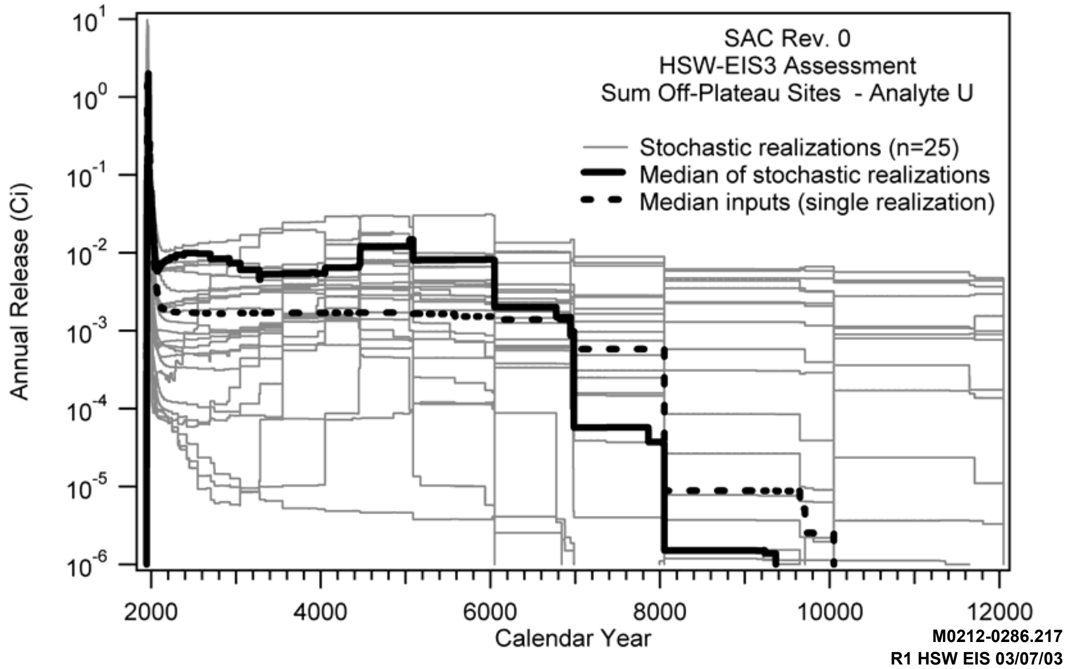

Figure L.37. SAC Results for Annual Vadose Zone Release of Uranium from All Other Sites Outside the 200 East and 200 West Areas

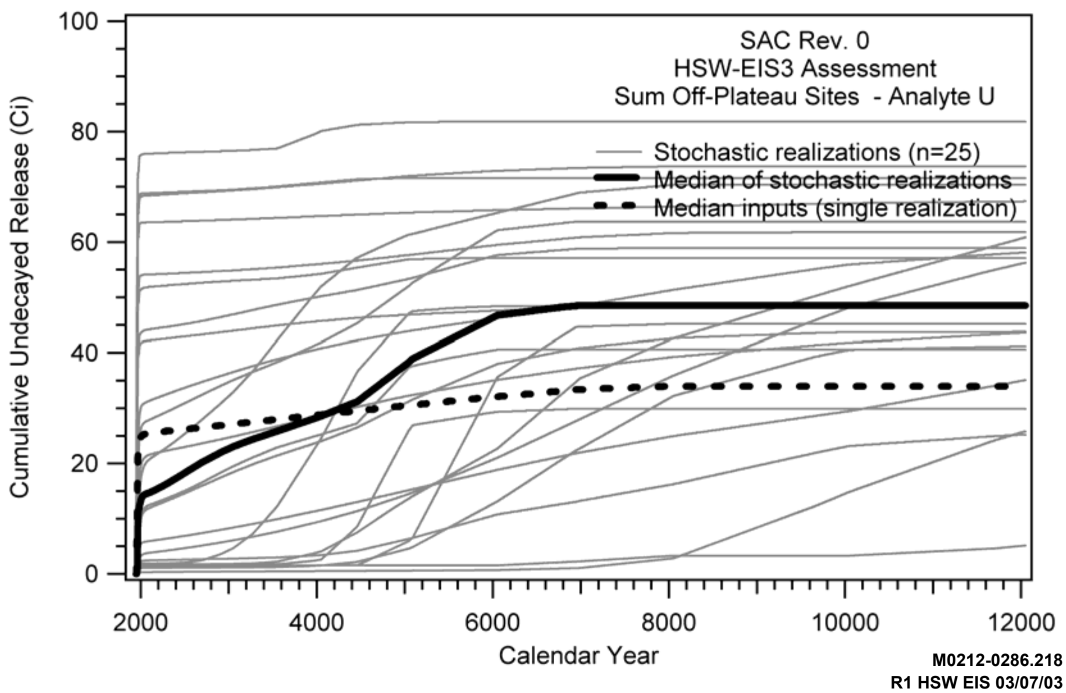

Figure L.38. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from All Other Sites Outside the 200 East and 200 West Areas

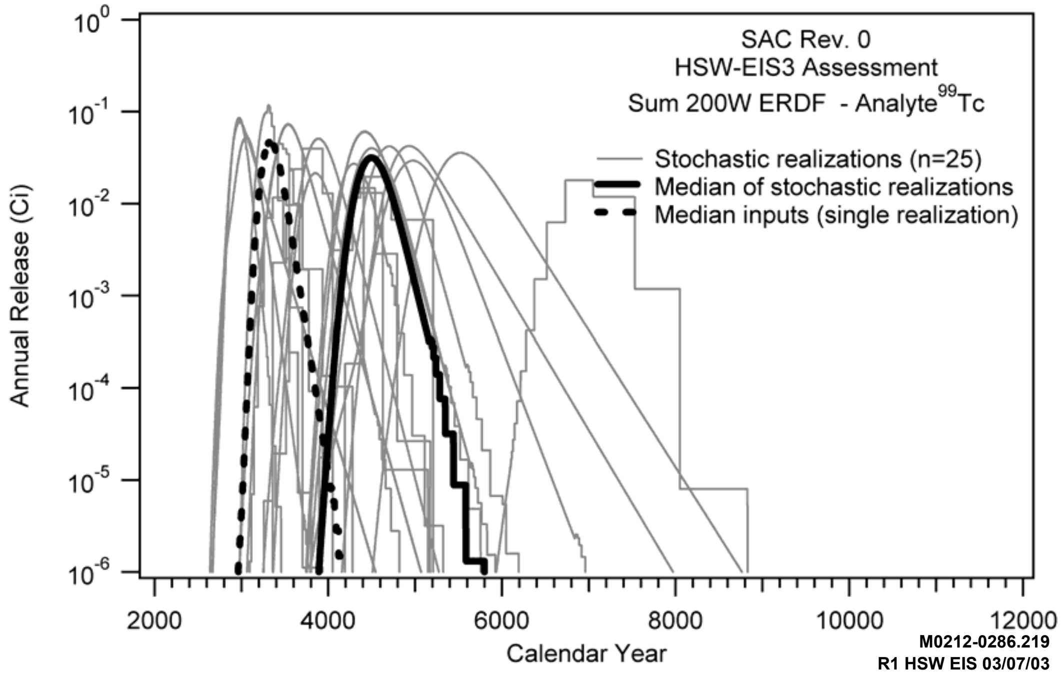

Figure L.39. SAC Results for Annual Vadose Zone Release of Technetium-99 from ERDF

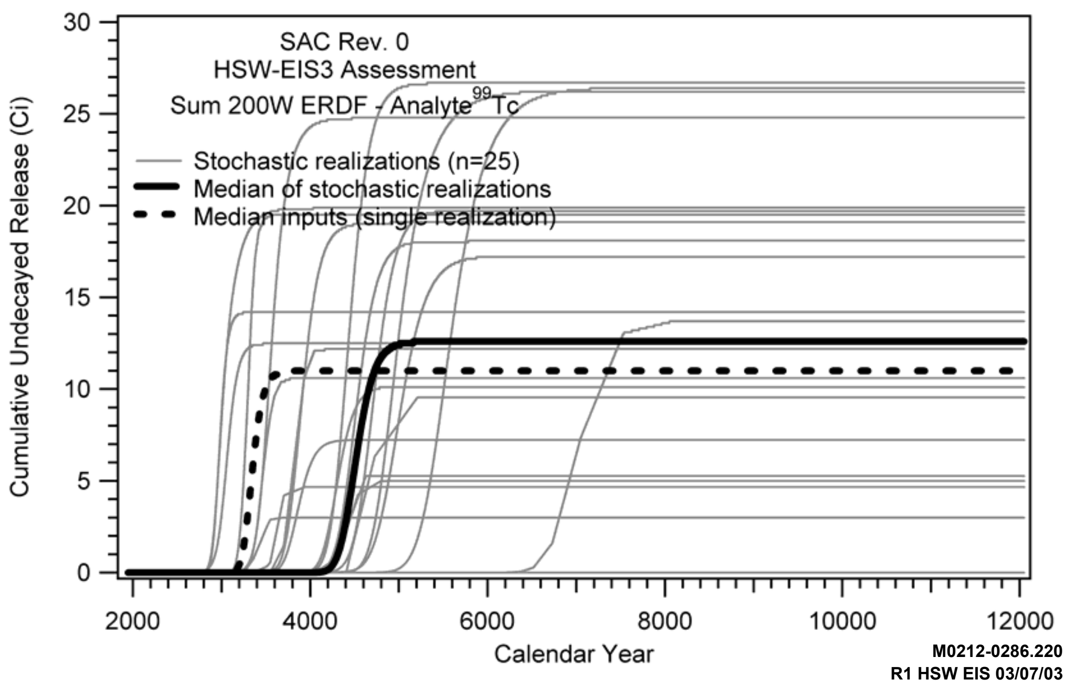

Figure L.40. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from ERDF

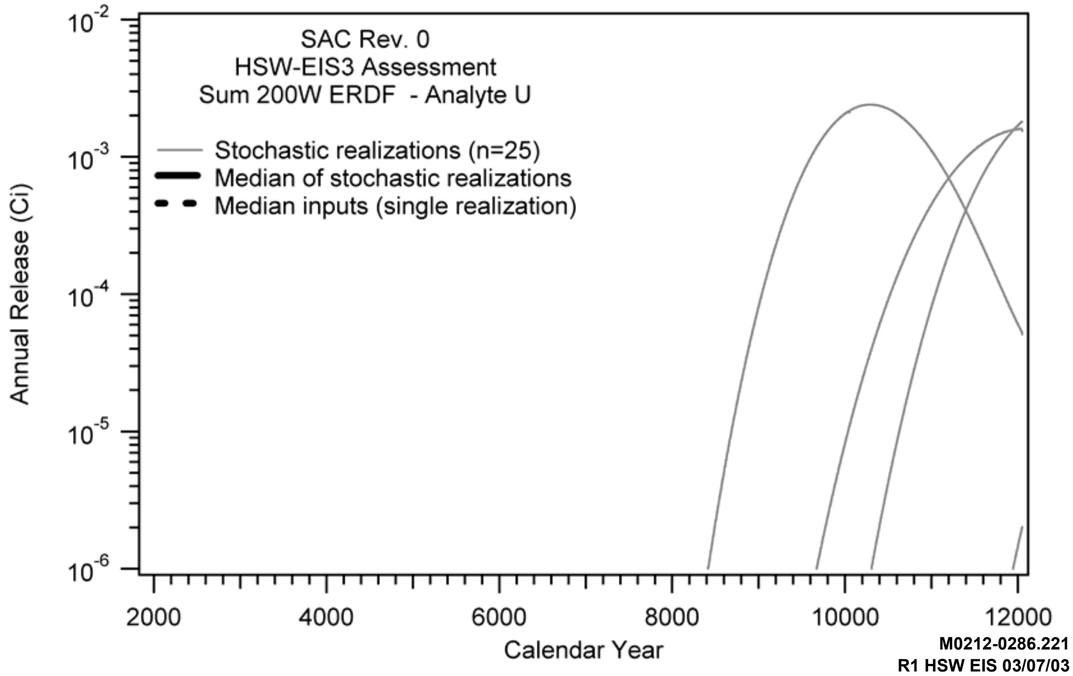

Figure L.41. SAC Results for Annual Vadose Zone Release of Uranium from the ERDF

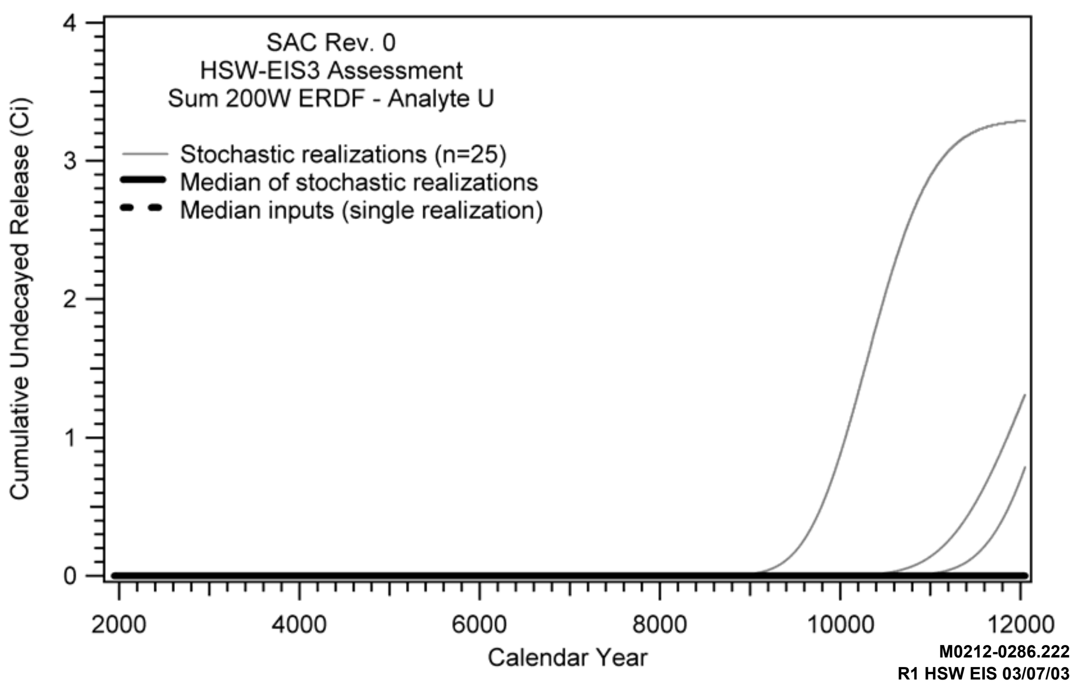

Figure L.42. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from the ERDF

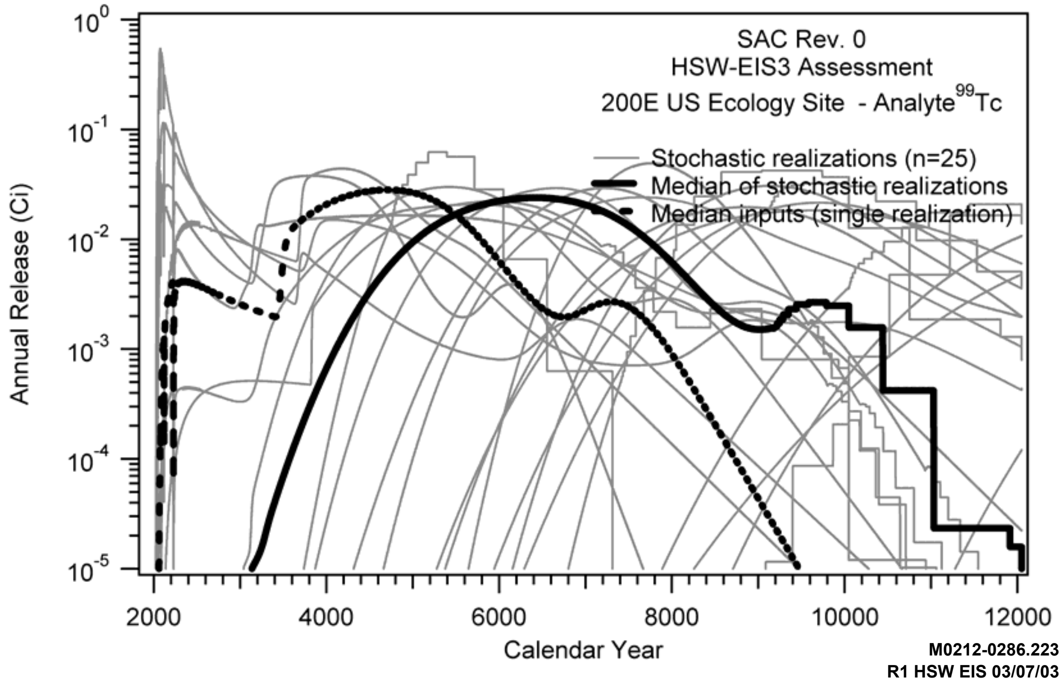

Figure L.43. SAC Results for Annual Vadose Zone Release of Technetium-99 from the Commercial Low-Level Radioactive Waste Disposal (US Ecology, Inc.) Site

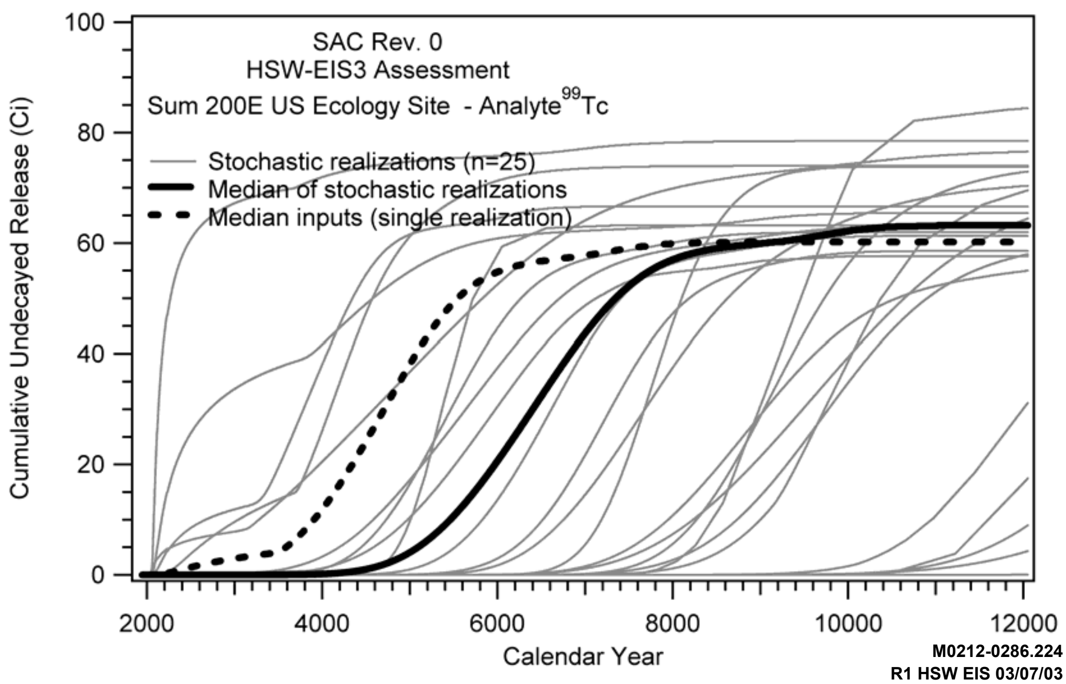

Figure L.44. SAC Results for Cumulative (undecayed) Vadose Zone Release of Technetium-99 from the Commercial Low-Level Radioactive Waste Disposal (US Ecology, Inc.) Site

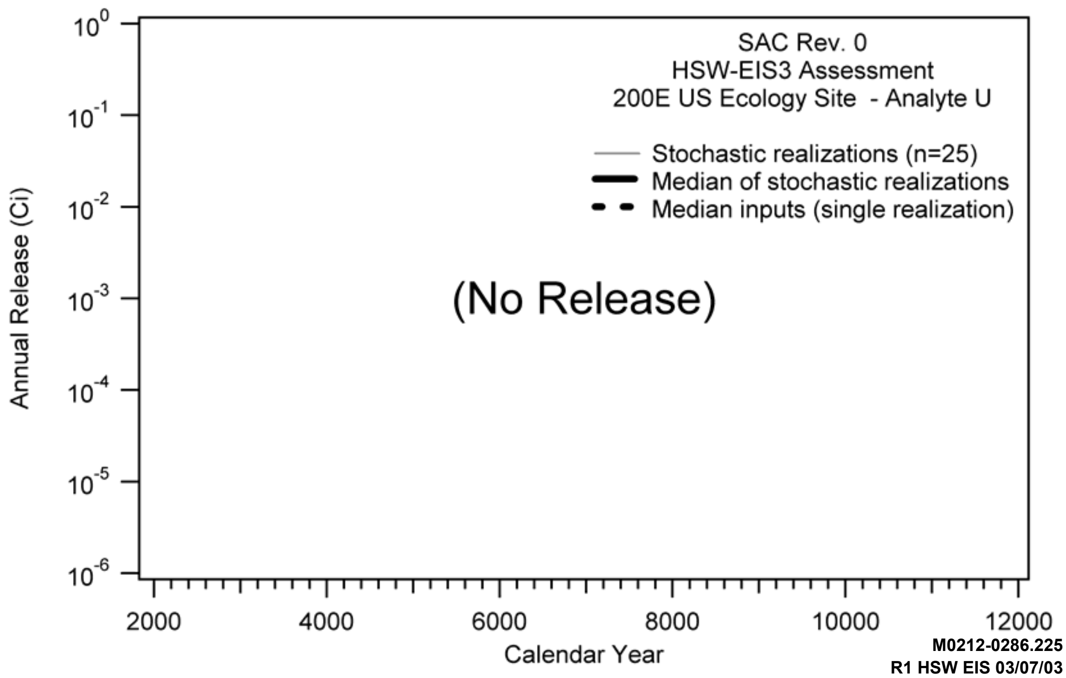

Figure L.45. SAC Results for Annual Vadose Zone Release of Uranium from the Commercial Low-Level Radioactive Waste Disposal (US Ecology, Inc.) Site

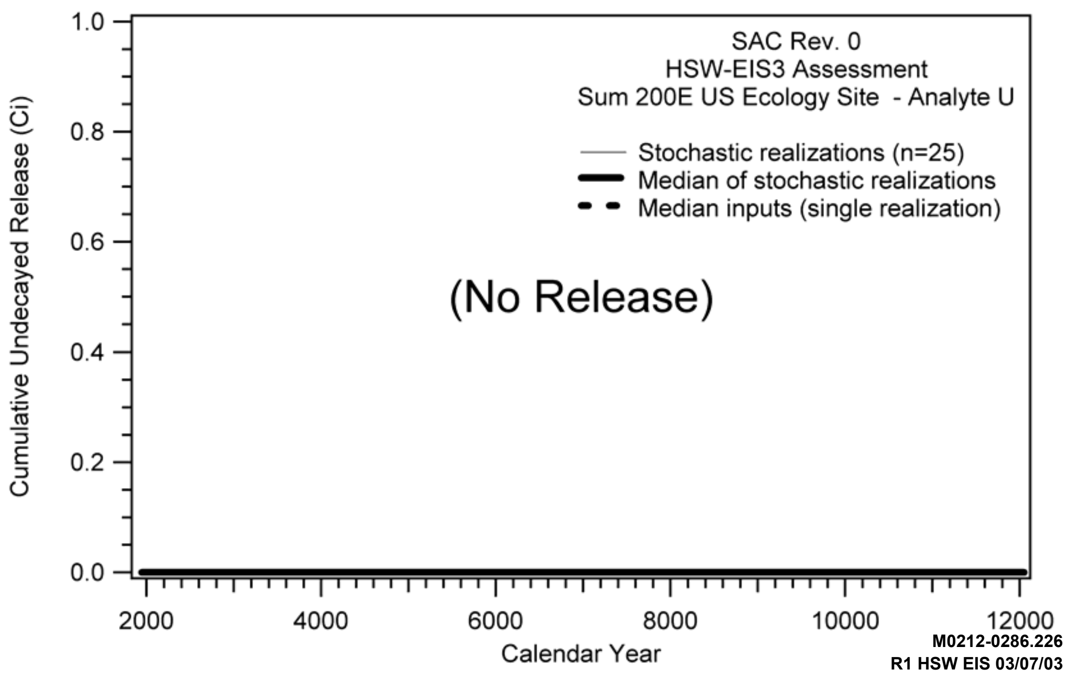

Figure L.46. SAC Results for Cumulative (undecayed) Vadose Zone Release of Uranium from the Commercial Low-Level Radioactive Waste Disposal (US Ecology, Inc.) Site

L.3.2 Drinking Water Dose at Selected 200 East and 200 West Area Locations

Doses to humans calculated using the SAC software and data are summarized in this section. The exposure scenario has an adult human drinking 2 L per day of contaminated groundwater. The stochastic capability of SAC was employed for these simulations, so the following results are shown in each plot in this section:

- Individual stochastic results (25 realizations) are shown in black.

- The median result of the 25 realizations—that is, the realization that resulted in the median integrated cumulative dose in the year 12050 A.D. (at the end of the simulation)—is shown in blue.

- The median-inputs simulation—a separate single-realization simulation with SAC using the median value of all stochastic input variables—is shown in red.

The variability in the stochastic results is due to variability in the inventory, release, and transport of technetium-99 and uranium. The human dose calculations use fixed inputs.

The doses provided in this section are based on all waste at the Hanford Site except the ILAW, melters, and naval reactor compartments. Cumulative releases to groundwater for HSW excluding ILAW disposed of in the Central Plateau range from approximately 323 to approximately 445 Ci for technetium-99 during the 10,000-year analysis period. This compares with a range of release to groundwater between approximately 1530 and 2310 Ci of technetium-99 for all Hanford wastes except ILAW. The contribution from HSW excluding ILAW would amount to about 20 percent of the cumulative release from Hanford sources excluding ILAW. The median release of technetium-99 from HSW excluding ILAW was approximately 390 Ci while the median release for all Hanford sources except ILAW was approximately 2000 Ci. The ILAW cumulative release of technetium-99 for the base case (Mann et al. 2001) considering the full technetium-99 inventory was approximately 86 curies by the end of the 10,000-yr post-closure period. Accordingly the contribution from HSW including ILAW would amount to about 25 percent of the cumulative release from all Hanford sources after 10,000 years.

For uranium, the cumulative releases to groundwater for Hanford solid waste disposed of in the Central Plateau range from 0 to approximately 94 Ci. However of all realizations simulated, no realizations showed any release to groundwater from HSW in the 200 East Area, and only 5 of 25 realizations show any release of uranium to groundwater from HSW in the 200 West Area. Thus, in an average (or median) sense, HSW deposits would release no uranium to groundwater over the 10,000 yr period of analysis. This compares with a median release of approximately 84 Ci and a range of release to groundwater from the 25 realizations of between approximately 10 to 300 Ci of uranium for all Hanford wastes except ILAW. Of the five realizations of non-zero uranium release from HSW in the 200 West Area, the cumulative release ranged from 0 to approximately 90 Ci. The contribution from uranium in Hanford solid waste lies between 0 and 30 percent of the cumulative release from all Hanford sources. However, the median release of uranium from Hanford solid waste was zero while the median release for all Hanford sources (except ILAW) was approximately 84 Ci.

L.3.2.1 Drinking Water Dose at the Northeast Corner of the 200 West Area

The drinking water dose to a human from technetium-99 using groundwater approximately 1 km (0.62 mi) outside the northeast corner of 200 West Area is provided in Figure L.47. The location was chosen to represent the highest doses from the local groundwater plume. The drinking water dose to a human from uranium at the same location is provided in Figure L.48. Neither of these figures included ILAW waste-form impacts explicitly. However, ILAW disposal occurs in the 200 East Area, and existing and future groundwater flow will conduct plumes from ILAW release away from the 200 West Area location shown in these figures. The data for technetium-99 show peaks early and again after approximately 3000 years. Figure L.47 exhibits a peak dose from technetium-99 in the range of 1 to 3 mrem/yr and a median of less than 2 mrem/yr with much lower consequences in the 7000 to 10,000-year time frame (that is, a range of 0.001 to 0.01 mrem/yr and a median less than 0.002 mrem/yr). Figure L.48 exhibits a peak dose from uranium (that is, a range of 0.01 to 0.3 mrem/yr and a median of approximately 0.05 mrem/yr) and considerable variability in later years because of the sorption model for uranium (that is, a range of 0.0001 to 7 mrem/yr and a median of approximately 0.04 mrem/yr).

L.3.2.2 Drinking Water Dose at the Southeast Corner of the 200 East Area

The drinking water dose to a human from technetium-99 using groundwater from approximately 1 km (0.62 mi) outside the southeast corner of 200 East Area is provided in Figure L.49. The location was chosen to represent the highest doses from the local groundwater plume. The drinking water dose to a human from uranium at the same location is provided in Figure L.50. Neither of these figures includes ILAW waste-from impacts. The technetium-99 results show peaks early and again throughout the 10,000-year period. Figure 5.49 exhibits a peak median dose from technetium-99 in the range of 0.3 to 2 mrem/yr during the 10,000-year period. Peaks within all realizations range to 100 mrem/yr. Figure 5.50 exhibits a peak median dose from uranium of less than 1 mrem/yr early with a long-term median value of less than 0.01 mrem/yr. There is considerable variability in later years because of the sorption model for uranium (that is, after 10,000 years, there is a range of approximately 0.001 to 1 mrem/yr, but the median is less than 0/01 mrem/yr).

L.3.2.3 Drinking Water Dose at the Northwest Corner of the 200 East Area

The drinking water dose to a human from technetium-99 using groundwater from approximately 1km (0.62 mi) outside the northwest corner of 200 East Area is provided in Figure L.51. The location was chosen to represent the highest doses from the local groundwater plume. The drinking water dose to a human from uranium at the same location is provided in Figure L.52. These figures exclude the influence of the ILAW waste-form impact. The technetium-99 results show peaks early and again throughout the 10,000-year period. Figure L.51 exhibits a peak median dose from technetium-99 in the range of 0.1 to 3 mrem/yr during the 10,000-year period. Figure 5.52 exhibits a peak median dose from uranium of approximately 3 mrem/yr with a long-term median value of less than 0.01 mrem/yr. There is considerable variability in later years because of the sorption model for uranium (that is, after 10,000 years, there is range of approximately 0.001 to 1 mrem/yr, but the median is less than 0.01 mrem/yr).

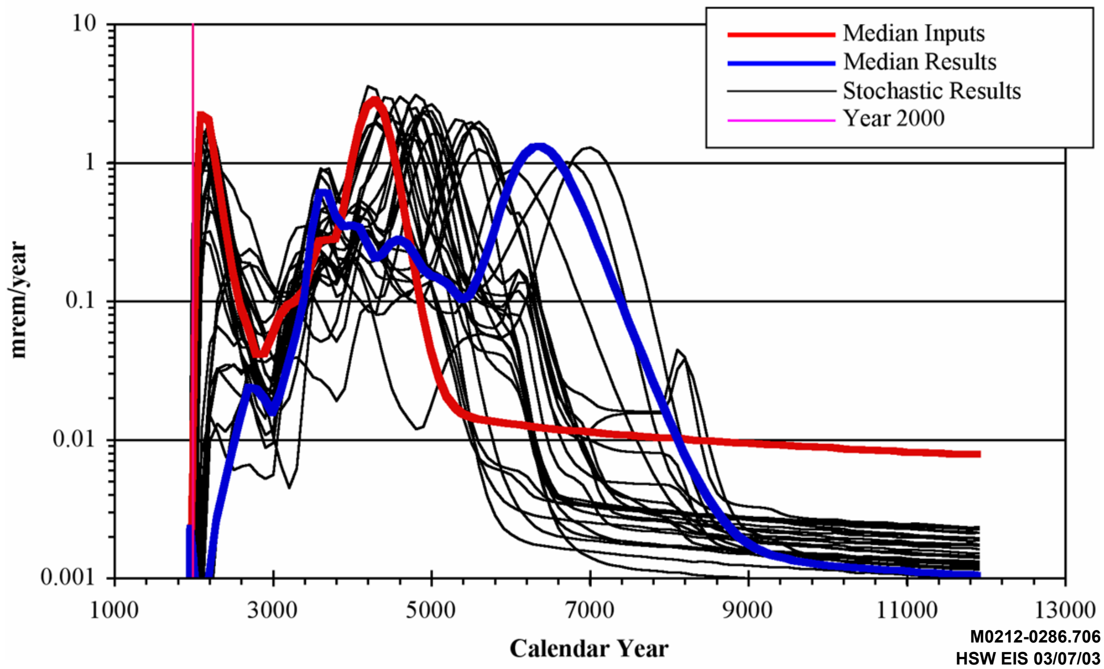

Figure L.47. Annual Drinking Water Dose from Technetium-99 in Groundwater 1 Kilometer Northeast of the 200 West Area

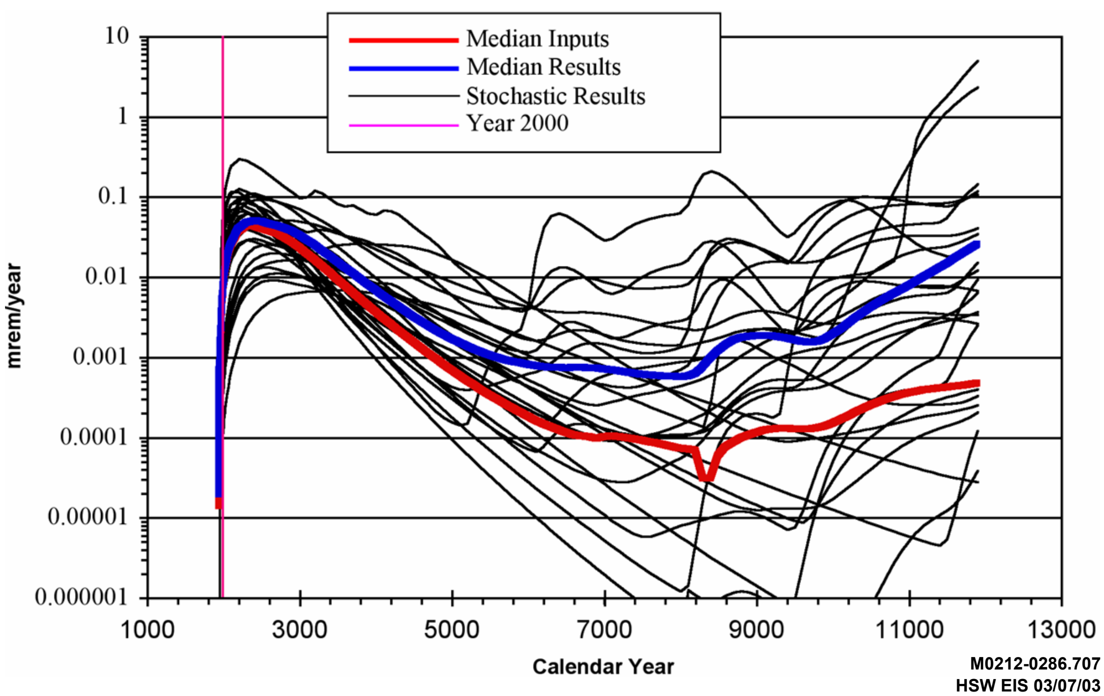

Figure L.48. Annual Drinking Water Dose from Uranium in Groundwater 1 Kilometer Northeast of the 200 West Area

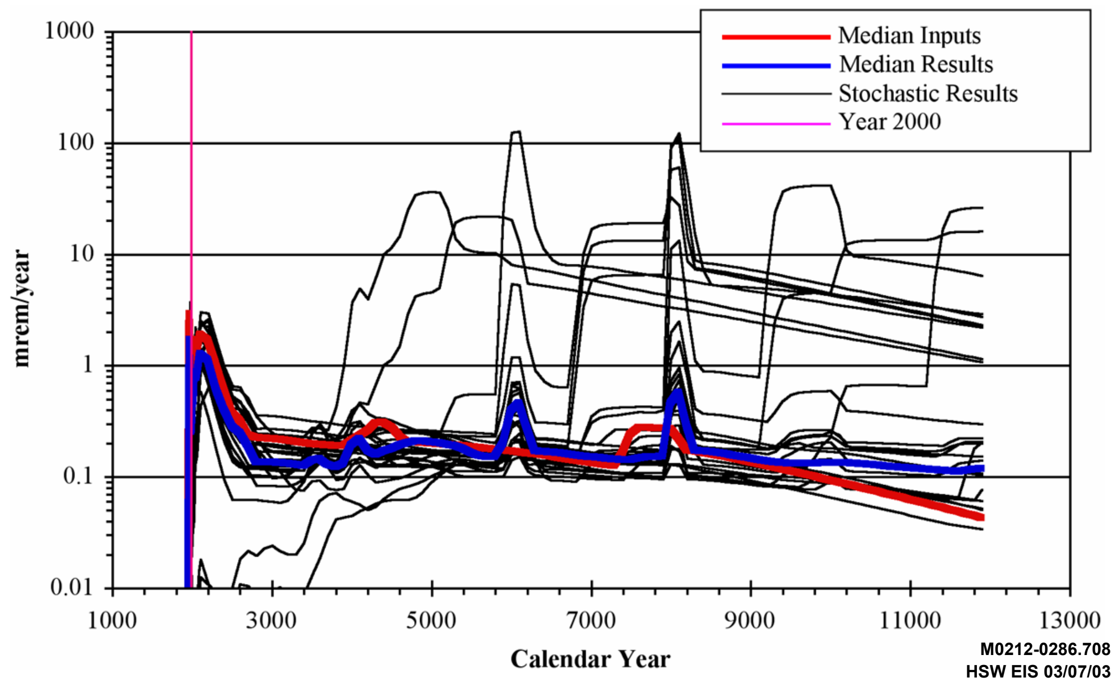

Figure L.49. Drinking Water Dose from Technetium-99 in Groundwater 1 Kilometer Southeast of the 200 East Area from All Hanford Sources Except ILAW, Melters, and Naval Reactors

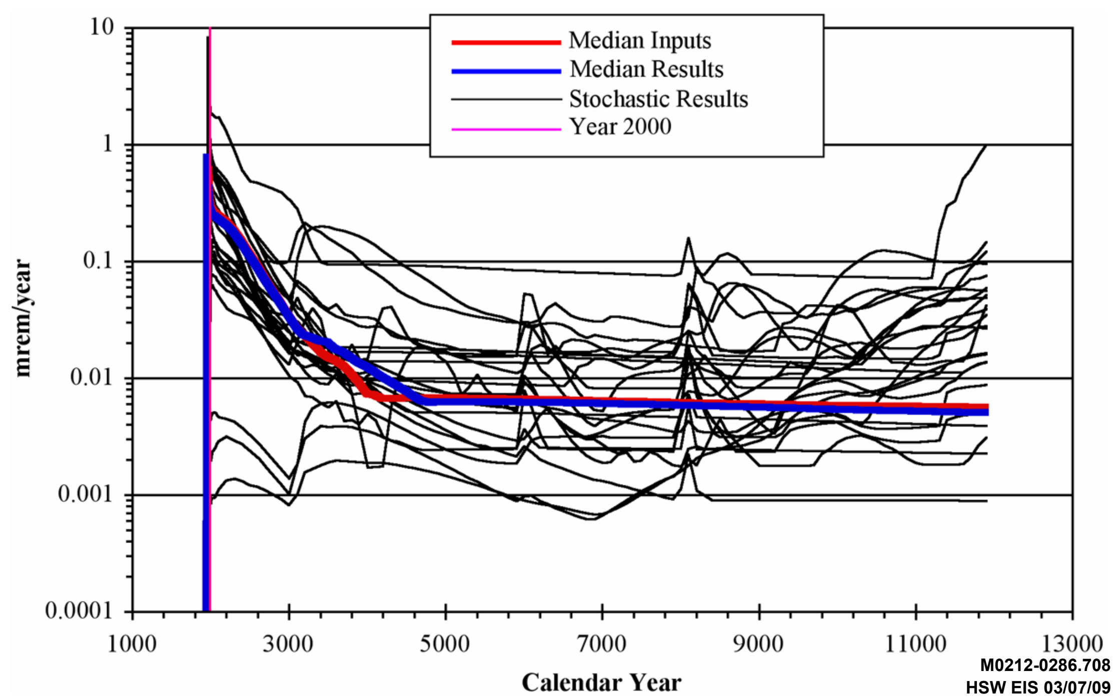

Figure L.50. Drinking Water Dose from Uranium in Groundwater 1 Kilometer Southeast of the 200 East Area from All Hanford Sources Except ILAW, Melters, and Naval Reactors

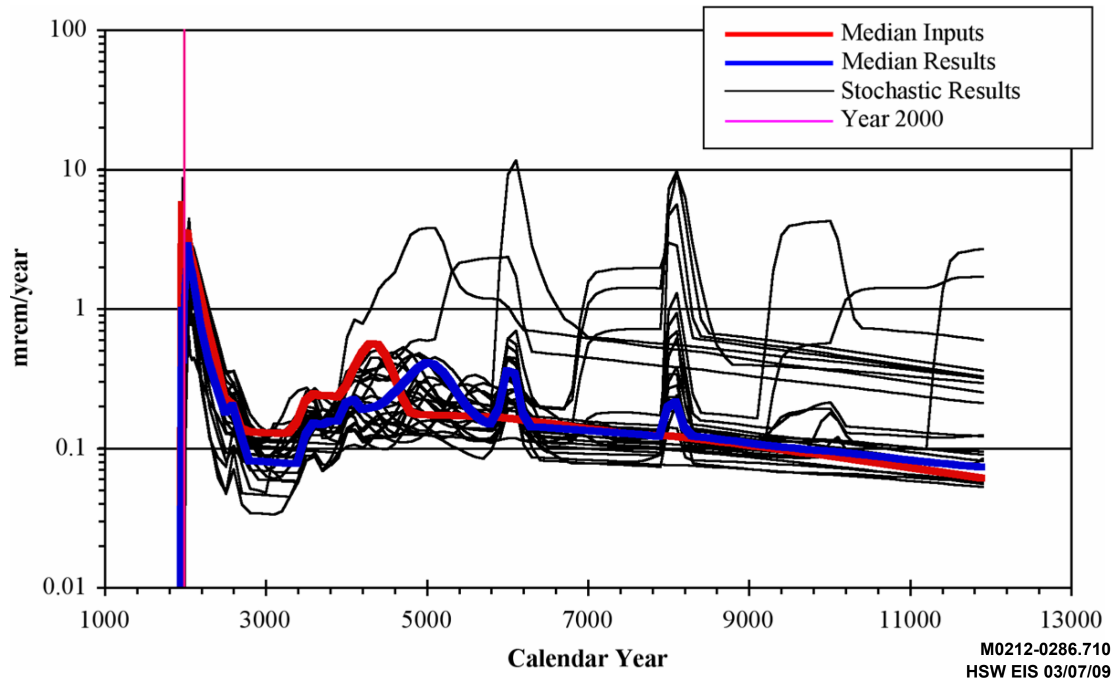

Figure L.51. Drinking Water Dose from Technetium-99 in Groundwater 1 Kilometer Northwest of the 200 East Area from All Hanford Sources Except ILAW, Melters, and Naval Reactors

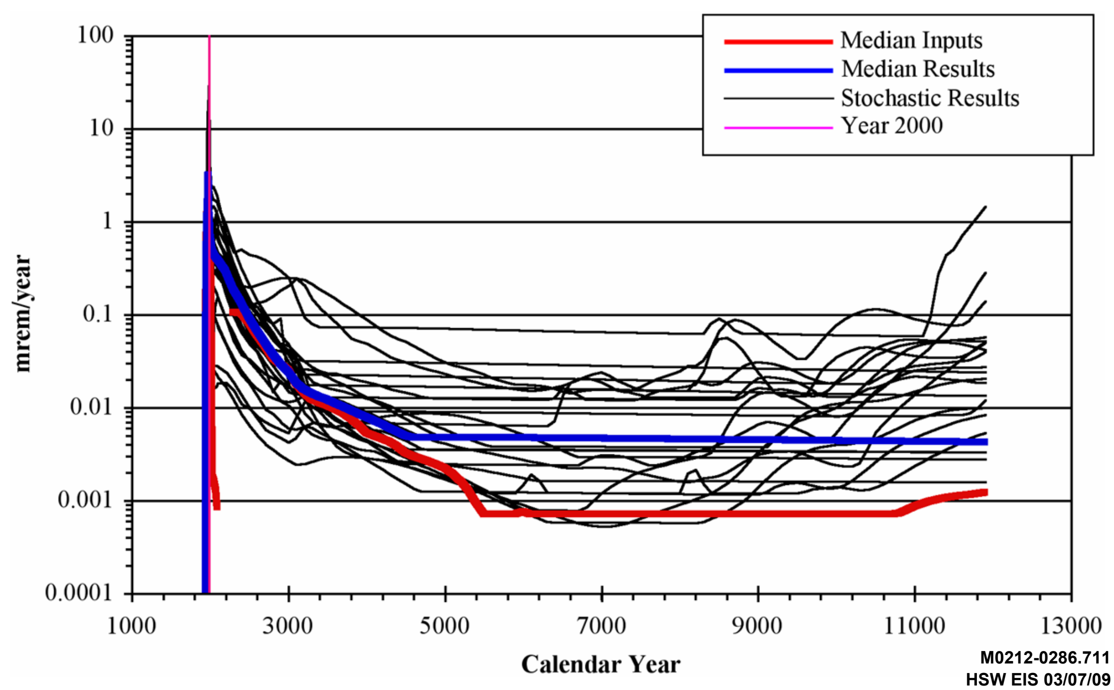

Figure L.52. Drinking Water Dose from Uranium in Groundwater 1 kilometer Northwest of the 200 East Area from All Hanford Sources Except ILAW, Melters, and Naval Reactors

L.3.3 Dose from Columbia River Water at the City of Richland Pumping Station

Annual dose to humans based on consumption of river water is summarized in this section. The exposure scenario has an adult human drinking 2 liters per day of contaminated river water from the modeled near-shore point nearest the City of Richland Pumping Station. The stochastic capability of SAC was employed for these simulations, so the following results are shown in each plot in this section:

- Individual stochastic results (25 realizations) are shown in black.

- The median result of the 25 realizations—that is, the realization that resulted in the median integrated cumulative dose in the year 9900 A.D.—is shown in blue. Although the groundwater simulations continued through the year 12050 A.D., the river simulations were terminated at the year 9900 A.D. due to software design constraints.

- The median-inputs simulation—a separate single-realization simulation with SAC using the median value of all stochastic input variables—is shown in red.

The variability in the stochastic results is due to the inventory, release, and transport of technetium-99 and uranium. The human dose model uses fixed inputs in the calculations. The doses provided in this section are based on all waste at the Hanford site and do not include background concentrations in the river. Thus, the doses are due entirely to Hanford contaminants, with most of the dose due to waste forms other than solid wastes.

L.3.3.1 Drinking Water Dose at the City of Richland Pumping Station

The drinking water dose to a human from technetium-99 using water concentrations calculated near the City of Richland Pumping Station is provided in Figure L.53. This location is downriver from all groundwater plumes of Hanford origin. The maximum estimated annual dose from technetium-99 over all realizations from the year 2000 through 9900 A.D. is less than 0.00008 mrem/yr, while the peak median dose was approximately 0.00004 mrem/yr. The annual drinking water dose to a human from uranium at the same location is provided in Figure L.54. The maximum annual dose from uranium over all realizations from the year 2000 through 12050 A.D. is less than 0.002 mrem/yr, while the peak median dose was approximately 0.00005 mrem/yr.

L.3.4 Annual Drinking Water Dose at Selected 200 East Area and Columbia River Locations from Hanford Sources Including ILAW

The deterministic capability of SAC was employed with results of the ILAW performance assessment (Mann et al. 2001), which were scaled to current inventory estimates to provide an initial estimate of the cumulative impact of all Hanford sources including ILAW. These deterministic results portray the median-inputs case of the initial assessment using SAC and the base case of the ILAW performance assessment (Mann et al. 2001). Essentially, the 2 L/d dose impacts from the ILAW inventories of technetium-99 and uranium reported in the ILAW performance assessment (Mann et al. 2001) are

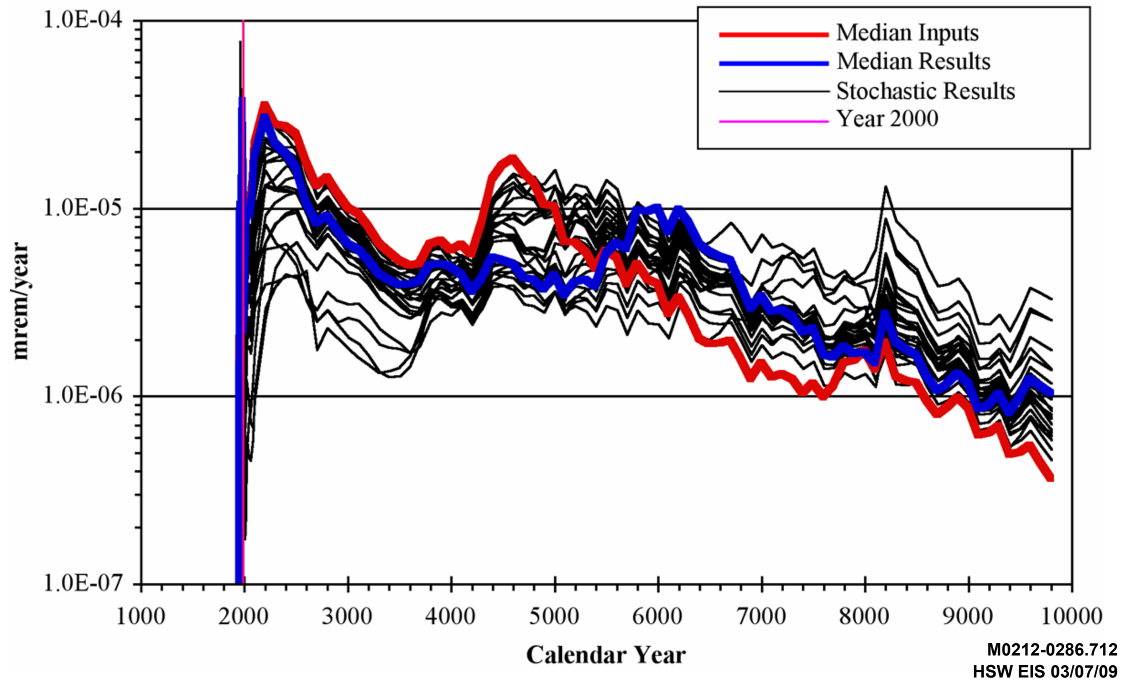

Figure L.53. Drinking Water Dose at the City of Richland Pumping Station from Technetium-99 Due to All Hanford Sources Except ILAW, Melters, and Naval Reactors

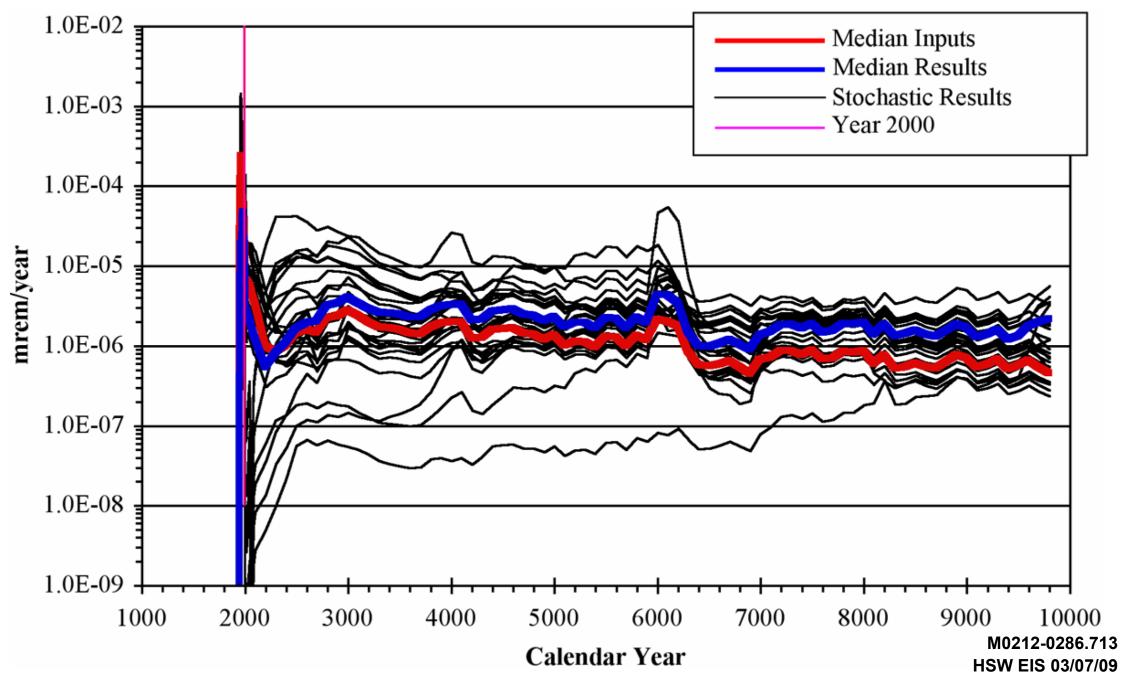

Figure L.54. Drinking Water Dose at the City of Richland Pumping Station from Uranium Due to All Hanford Sources Except ILAW, Melters, and Naval Reactors superimposed on the SAC median-value simulation. A series of three plots show combined SAC and ILAW results at a point 1-km southeast of the 200 East Area and at a point of analysis near the shore of the Columbia River at the City of Richland Pumping Station.

The cumulative impact for all Hanford sources is provided in Figure L.55. This is the annual drinking water dose from a 2 L/d drinking water scenario for technetium-99 at a point of analysis approximately 1 km (0.62 mi) southeast of the 200 East Area. The curve is a composite of the SAC initial assessment result and the base case ILAW result (Mann et al. 2001). To account for the current estimate of 25,500 Ci of technetium-99 in low-activity waste from the single- and double-shell tanks, the ILAW analysis of a 5790 Ci technetium-99 source has been scaled accordingly.

The cumulative result shown in Figure L.55 exhibits an initial peak prior to the year 2000 and a secondary peak in the next two centuries. The secondary peak is approximately 1 mrem/yr and is related to releases from liquid discharge sites in the 200 East Area. Additional, but lower, secondary peaks, 0.03 mrem/yr, appear in approximately 4300 A.D. and 7500 A.D. Releases from solid waste disposal facilities in the 200 West Area are responsible for the earlier of these two secondary peaks. Tank waste residuals releasing from the 200 East Area, modeled as 1 percent residual tank waste volume in a salt cake waste form, are responsible for the last secondary peak.

By the end of the 10,000-year, post-closure period, the cumulative dose from all Hanford sources is approximately 0.06 mrem/yr, of which approximately 0.02 mrem/yr is from ILAW and 0.04 mrem/yr is from all other Hanford sources. Based on uncertainty in the groundwater conceptual model, the ILAW contribution may be four times larger. Thus, the ILAW contribution may be 0.08 mrem/yr and may be comparable to or larger than that for all other Hanford sources. For this alternate conceptual model, the cumulative 2-L/d dose would be approximately 0.12 mrem/yr at 10,000 years post-closure. Note that ILAW release and associated dose impacts play a role in the last several thousand years, and do not substantially alter the secondary peaks described earlier.

A comparison of consequences from consuming 2 L/d of river water with and without the ILAW release of technetium-99 and uranium are provided in Figures L.56 and L.57 for the Columbia River at the City of Richland Pumping Station. Results from the SAC median-input case of the initial assessment and from the ILAW performance assessment base case are shown on each figure. Figure L.56 shows that dose originating from the low-activity waste source containing 25,500 Ci of technetium-99 is approximately equivalent to or slightly greater than the dose originating from all other Hanford wastes. The cumulative dise is 1.0×10^{-6} mrem/yr at 10,000 years post-closure, and this result is five orders-of-magnitude below the dose predicted at the 200 East area location.

The comparison graphic of consequences from uranium is provided in Figure L.57. After 10,000 years post-closure and at the time of greatest ILAW uranium impact, the dose from uranium is estimated to be approximately an order-of-magnitude below that of all other Hanford sources. Combined, the estimated dose is less than 1.0×10^{-6} mrem/yr.

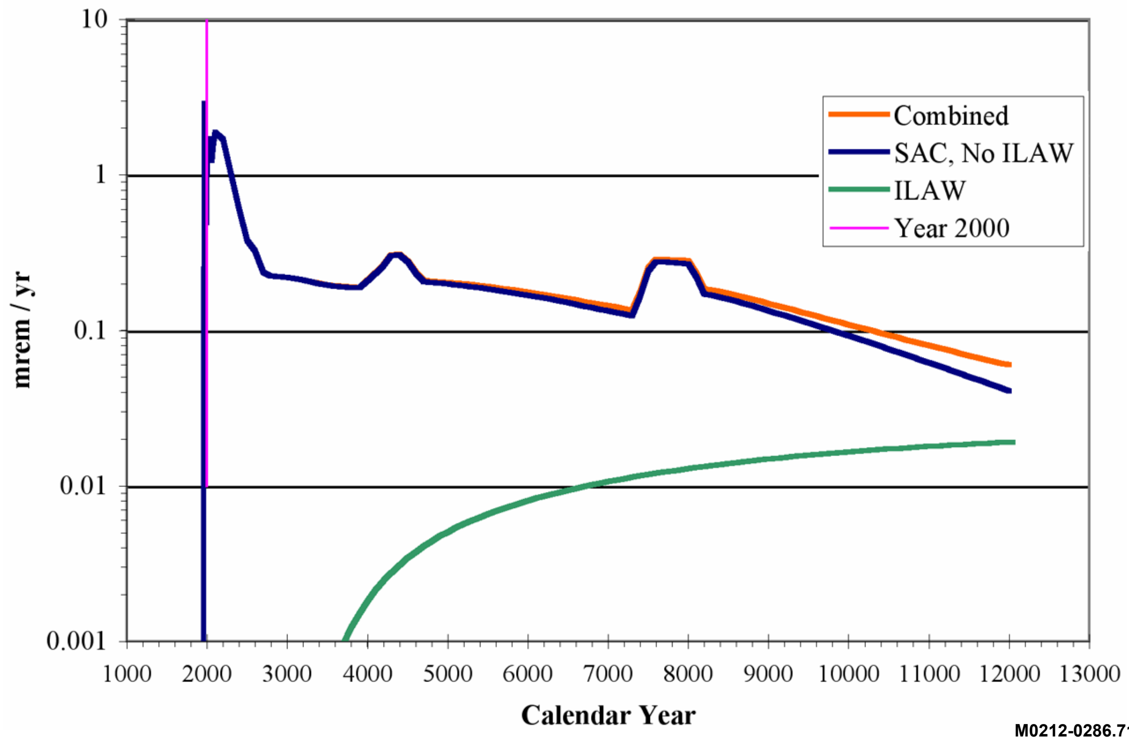

Figure L.55. Annual Drinking Water Dose from Technetium-99 in Groundwater 1 Kilometer Southeast of the 200 East Area from Hanford Sources Including ILAW

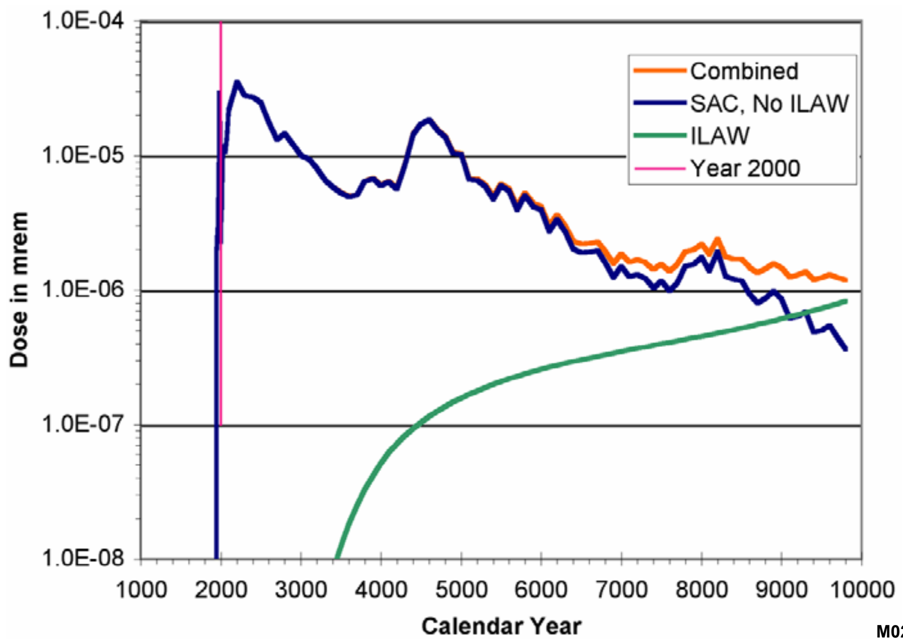

Figure L.56. Annual Drinking Water Dose from Technetium-99 in the Columbia River at the City of Richland Pumping Station from Hanford Sources Including ILAW

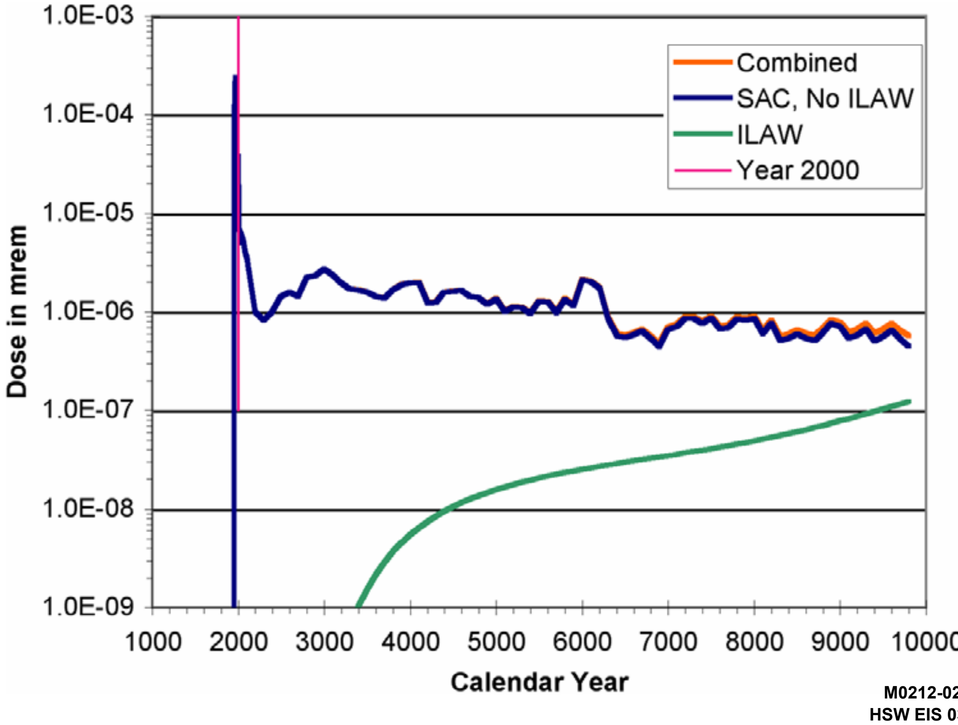

Figure L.57. Annual Drinking Water Dose from Uranium in the Columbia River at the City of Richland Pumping Station from Hanford Sources Including ILAW

The dose from technetium-99 at the City of Richland (Figure L-61) exhibits the secondary peak structure seen in the dose from technetium-99 near the 200 East Area. However, the dose from consumption of river water exhibits a greater variability in both Figures L.56 and L.57 because of the underlying variability associated with Columbia River discharge. Secondary peak structure is greatly subdued in the dose from uranium plot (Figure L.57) because uranium is sorbed onto subsurface sediments and river sediments.

The results are an approximation achieved by superimposing the results of two independently conducted analyses. Nevertheless, the results indicate that the contribution from ILAW, which represents a substantial fraction of the technetium-99 inventory at Hanford, while being equivalent to the initial assessment results does not substantially influence the overall dose prediction made in the initial assessment for all wastes other than ILAW.

L.4 References

Bergeron, M. P., E. J. Freeman, S. K. Wurstner, C.T. Kincaid, F.M. Cooney, D.L. Strenge, R.L Aaberg, and P.W. Eslinger. 2001. *Addendum to Composite Analysis for Low-Level Disposal in the 200 Area Plateau of the Hanford Site*. PNNL-11800, Addendum 1, Pacific Northwest National Laboratory, Richland, Washington.